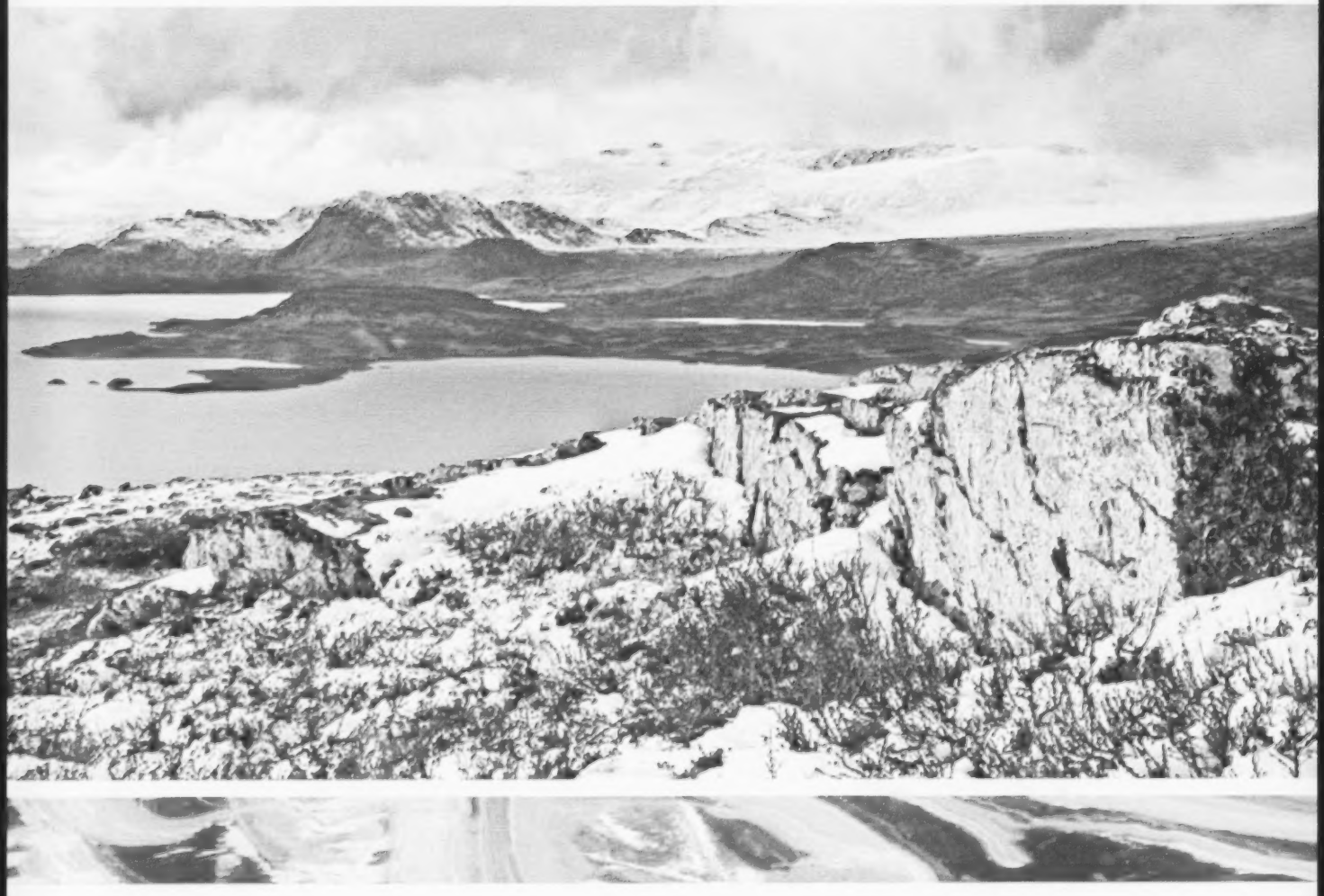
INRS

Université d'avant-garde

Centre - Eau Terre Environnement

Annual Report 2008-2009



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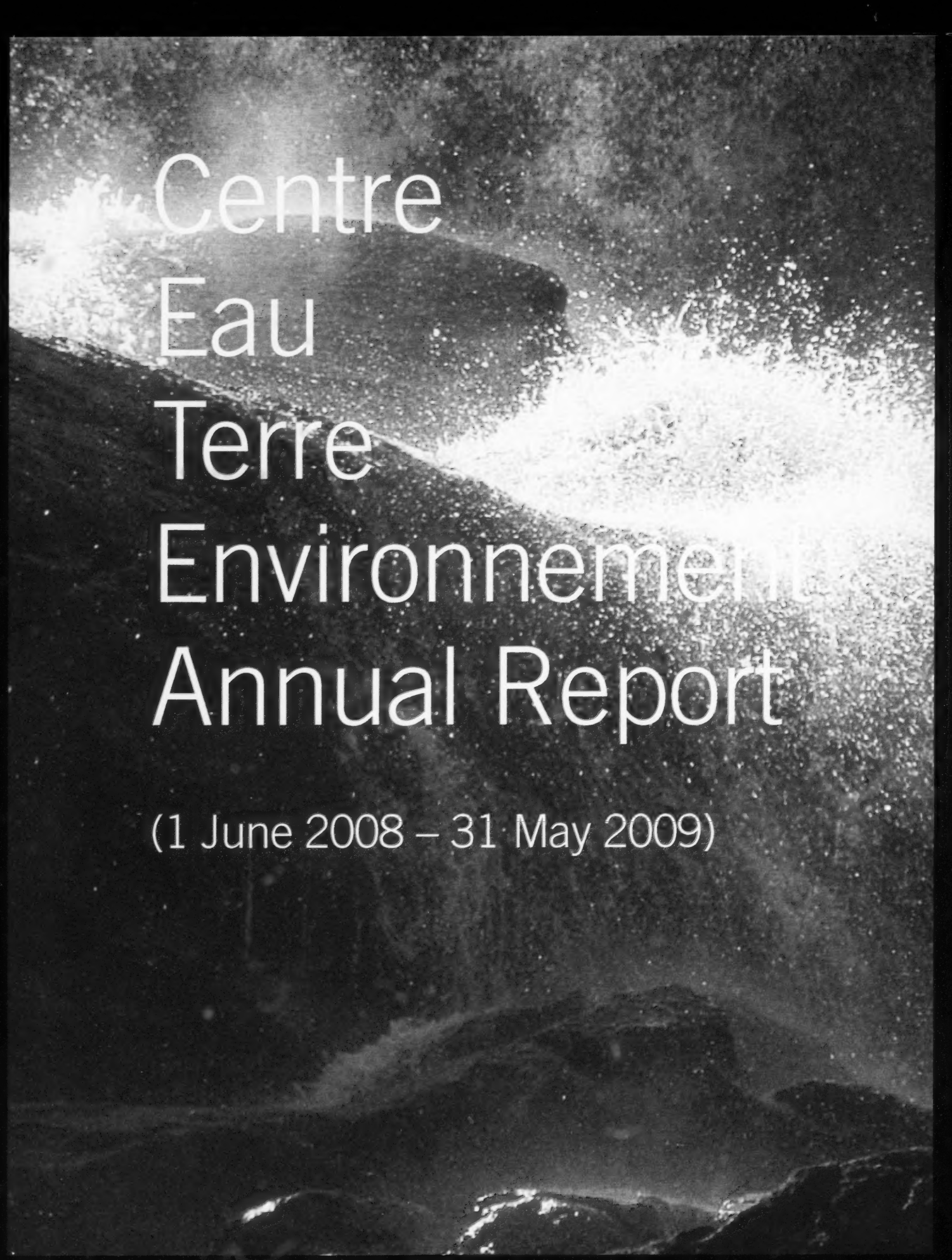
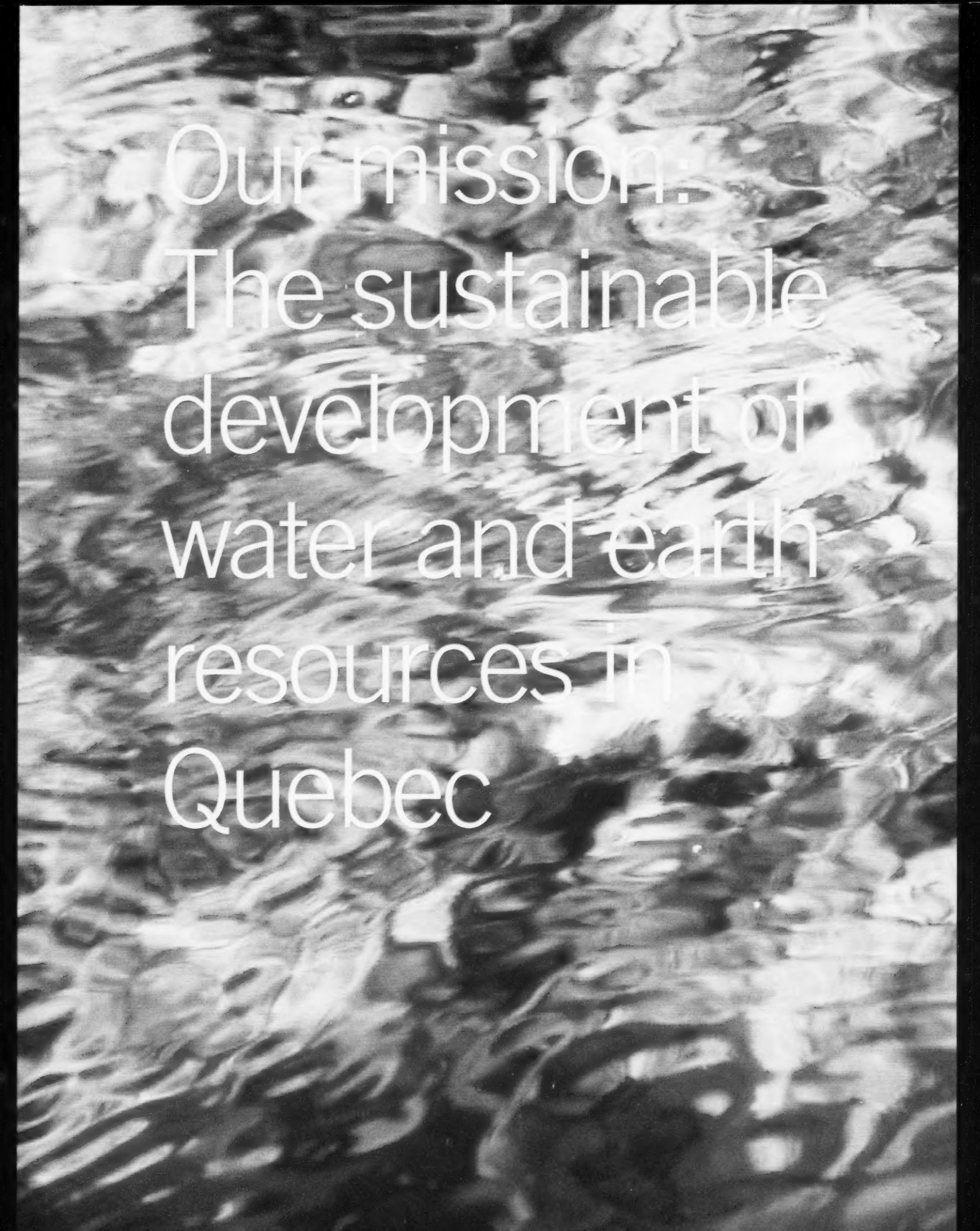


Centre Eau Terre Environnement Annual Report

(1 June 2008 – 31 May 2009)


Our mission:
The sustainable
development of
water and earth
resources in
Quebec

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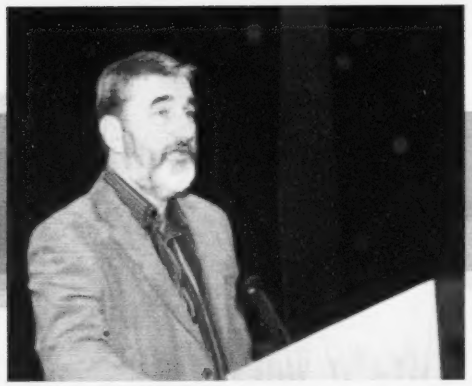
Message from the Director



I am pleased to present the 8th annual report of the *Centre Eau Terre Environnement* of the *Institut national de la recherche scientifique* (INRS) for the year 2008-2009. This report outlines the notable events of the year and describes the Centre's objectives and activities.

The mission of the Centre is to contribute to the sustainable development of Quebec's natural resources, particularly in the fields of water science, georesources such as minerals and fossil fuels, and the environment. The scientific program of the Centre is divided into four main research fields: hydrology, waste decontamination and reclamation, biogeochemistry and contamination issues, and geological sciences. Within each field, the main research projects carried out this year are briefly described.

The report contains a map highlighting the Centre's links throughout the world, including research sites, and the origins of students, fellows, professionals and collaborators. For example, 68 guest professors and researchers from a dozen countries around the world came to the Centre this year. Invited guests presented more than 24 seminars during the year.

Some notable events of the year

In spring 2008, the arrival of two new professor-researchers enhanced the Centre's research expertise. Paul Drevnick specializes in the biogeochemistry of contaminants in the aquatic environment; focusing on the environmental impacts of mercury. Bernard Giroux is a geophysicist. He is particularly interested in developing tools to characterize aquifers.

Our researchers and students were awarded many distinctions this year. For example, two students received awards of excellence for their PhD projects from the *Chapitre Saint-Laurent*, an organization in Quebec affiliated with two international groups, SRA (Society for Risk Analysis) and SETAC (Society of Environmental Toxicology and Chemistry): Isabelle Proulx (supervised by Professor Landis Hare) in 2008 and Raoul-Marie Couture (supervised by Professor Charles Gobeil) in 2009. Lyal Harris's research group (including Elena Konstantinovskaya, associate researcher and Jimmy Poulin, then a Master's student) received the David Elliot Best Paper Award from the Geological Association of Canada for an article they published in 2007 in *Tectonophysics*.

The *Centre géoscientifique de Québec* celebrated its 20th anniversary this year, it was inaugurated on 1 October 1988. The 20-years scientific collaboration between the *Centre Eau Terre Environnement* of the INRS and the Quebec division of the Geological Survey of Canada has improved knowledge in the fields of earth sciences and the environment.

In November, ecologist and activist Sheila Watt-Cloutier was awarded an honorary doctorate at the INRS convocation ceremony. A leader of the Inuit nation and one of the best advocates of the environmental cause, Ms. Watt-Cloutier has helped reveal the strong link that exists between climate change and human rights. Climate change is a central theme in the Centre's research program; it constitutes one of the four strategic axes of the program.

In April 2009, the first meeting of the Research Chair on Geological Sequestration of CO_2 was held. Professor Michel Malo holds this new chair. The meeting's theme was "The Capture and Sequestration of Carbon in Quebec: Who Are the Actors?" The chair is financed by Quebec's Ministry of Sustainable Development, Environment and Parks. Another grant from this ministry will enable the INRS to carry out an important study of groundwater resources in the Montérégie-Est region. Professor René Lefebvre leads this project, which will be carried out in partnership with the Geological Survey of Canada and regional organizations. The project will benefit from the INRS's expertise in aquifer characterization.

Other notable events of 2009 included the participation of several members of the Centre in the 10th Earth and Environmental Sciences Day, held in March, and the public outreach event organized in April as part of Earth Day activities.

This report thus highlights the main achievements of the Centre during 2008-2009. Credit for those achievements belongs to the entire *Centre Eau Terre Environnement* community, including the professor-researchers, students, postdoctoral and research fellows, and staff, all of whom contributed their share to the success of our establishment.

I sincerely thank everyone.

The Director,

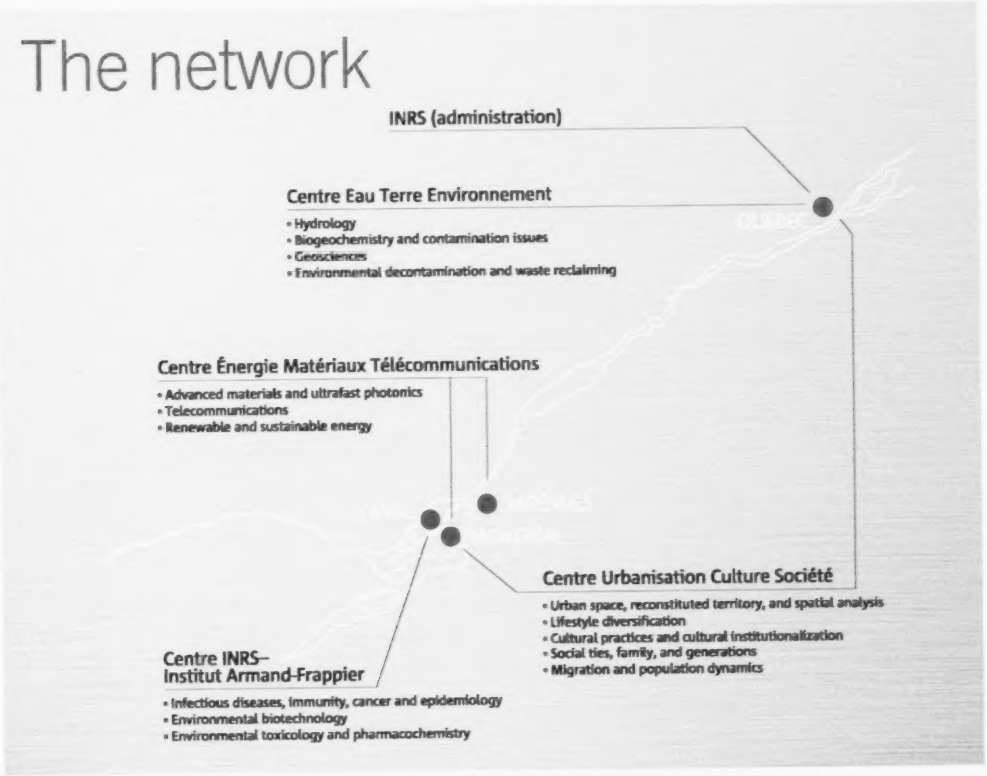
Yves Bégin

Centre Eau Terre Environnement and the INRS network

The mission of the *Institut national de la recherche scientifique* (INRS: Quebec's national institute of scientific research) is to conduct pure and applied research for the social, economic, and cultural benefit of Quebec. This university research institution seeks to train highly qualified professionals at the graduate level and ensure the transfer of knowledge and technologies in its areas of scientific expertise. It is also dedicated to the spread of science at the international level.

The INRS is composed of four research centres: *INRS – Institut Armand-Frappier* (health research), *Centre Énergie Matériaux Télécommunications* (research on energy, materials, and telecommunications), *Centre Urbanisation Culture Société* (research on urbanization, culture, and society), and *Centre Eau Terre Environnement* (research on water, earth, and the environment). The INRS offers to its students and professor-researchers an innovative research environment focused on society's needs.

The network


INRS (administration)
Centre Eau Terre Environnement
• Hydrology
• Biogeochemistry and contamination issues
• Geosciences
• Environmental decontamination and waste reclaiming
Centre Énergie Matériaux Télécommunications
• Advanced materials and ultrafast photonics
• Telecommunications
• Renewable and sustainable energy
Centre Urbanisation Culture Société
• Urban space, reconstituted territory, and spatial analysis
• Lifestyle diversification
• Cultural practices and cultural institutionalization
• Social ties, family, and generations
• Migration and population dynamics
Centre INRS–
Institut Armand-Frappier
• Infectious diseases, immunity, cancer and epidemiology
• Environmental biotechnology
• Environmental toxicology and pharmacochemistry

The *Centre Eau Terre Environnement* contributes to the INRS mission of research, education, and transfer of scientific and technical knowledge through its work on the integrated management, conservation, and sustainable development of water and earth resources. The Centre is based in downtown Quebec City within the urban campus of the *Université du Québec*, its large-scale laboratories are located at the Metropolitan Quebec Technology Park, and it has an environmental research station at Sacré-Coeur, in the Saguenay region.

A global vision for sustainable environmental development

The *Centre Eau Terre Environnement* is actively engaged in the sustainable development of Quebec, particularly in the fields of water science, geo-resources, and the environment. The Centre addresses major environmental issues of current concern to the world's governments, such as the need for reasonable and safe use of water and earth resources, the need to prevent environmental risks, and the need to respect natural ecosystems. The Centre is dedicated to finding practical solutions to environmental problems. These solutions are based on a thorough knowledge of natural processes, new environmental technologies, and good development practices. The Centre's vision is based on a strong environmental commitment and a rigorous and innovative scientific approach. Its research is at the forefront of scientific and technological advances, facilitating the protection and sustainable development of natural resources.

Some statistics about the Centre

At the *Centre Eau Terre Environnement* of the INRS there were in 2008–2009:

41 researcher-professors
12 emeritus and honorary professors
26 associate professors
68 invited researchers and professors

110 PhD students
80 Master's students
7 students in the Professional Master's program
29 postdoctoral fellows
94 undergraduate and graduate interns

137 articles published in scientific journals
22 published scientific communications
255 oral and poster presentations
9 books and book chapters
74 research reports (public and private)
19 PhD theses
18 Master's theses

6 graduate studies programs
6 research chairs

And many research units (laboratories, groups, networks, etc.)

Multidisciplinary research

The *Centre Eau Terre Environnement* of the *Institut national de la recherche scientifique* is a leader in multidisciplinary environmental research. The Centre's focus is on water and earth resources. Its research groups develop environmental technologies, cutting-edge methods of detecting environmental changes in aquatic ecosystems, innovative approaches to integrated management of resources, and techniques for the numerical modeling of underlying natural processes. The Centre's research is at the heart of scientific and technological innovations aimed at the protection and development of natural resources. Sustainable use of these resources requires approaches based on the prevention of possible impacts and reduction of potential risks rather than impact mitigation or site rehabilitation. Hence, the goal is to modify practices by integrating cleaner and more effective processes.

The scientific program of the Centre is divided into four main research fields: hydrology, waste decontamination and reclamation, biogeochemistry and contamination issues, and geological sciences. The multidisciplinarity of its research groups and their integration within national and international networks enable analysis of crucial questions such as risks related to natural hazards or contamination of human origin; impacts of and adaptations to climate change and extreme natural events; management of hydrological and mineral resources and the implications for regional planning; and restoration and decontamination technologies for urban and natural environments. The entire research community of the Centre confronts these questions, which constitute the strategic axes of its scientific program.

Ongoing hydrology research

Canada has approximately 6% and Quebec nearly 2% of the world's fresh water resources. Sustainable management of this vital resource is thus a priority research subject at the INRS. Indeed, the *Centre Eau Terre Environnement* hosts the most important group of university experts in water research in Canada. The Centre's expertise derives from its long experience in developing and applying numerical approaches to analysis and decision-making in different water management contexts. The tools developed are based on numerical hydrology, geomatics, and remote sensing. The group's multidisciplinarity allows thorough analysis of both resource availability and associated environmental problems.

The Centre's hydrology research focuses in particular on evaluating, modeling, and managing water resources (watershed hydrology), predictive statistics (statistical hydrology and climatology), infrastructure (urban hydrology), river environments (environmental hydraulics), and ocean physics (oceanography). The impacts of and adaptations to climate change is a central theme of the Centre's hydrology research.

• Watershed hydrology

Monique Bernier seeks to evaluate how remote sensing, and more specifically radar polarimetry data, can be used to monitor physical properties of river ice, snow cover, and soil conditions (humidity, frost) and to estimate wind resources.

Within the GEOIDE Network (Geomatics for Informed Decisions, www.geoide.ulaval.ca), she led the FRAZIL project (2005–2009). One of the project's products has been the automated production of river ice maps from RADARSAT-1/-2 images. The map production procedure was transferred to Quebec's Ministry of Public Security in 2009. Other researchers at the Centre, **Taha B.M.J. Ouarda**, **Karem Chokmani**, and honorary professor **Michel Leclerc**, were also involved in this project.

Monique Bernier adapted the river ice radar mapping procedure to the Nunavik context as part of the International Polar Year (IPY) Variability and Change in the Canadian Cryosphere project. To this end, her team met with Inuit representatives (to determine their needs), involved the community (to implement the procedure), and validated the data (using ground photography, overflights, field measurements). The maps produced have been made available to the Inuit community of Kuujjuaq via the Internet. High school students from this community were involved in all stages of the project.

Stéphane Mermoz, Yves Gauthier, and Maxime Rousseau taking an ice core, Kuujjuaq

She is also involved in the Permafrost and Climate Change in Northern Coastal Canada: Impacts and Adaptations for Communities project, which is part of phase II of the ArcticNet Network (www.arcticnet.ulaval.ca) research program. In this project, satellite and radar data are used to analyse and predict changes in the state of permafrost.

In addition, she leads one of the research projects of the new Wind Energy Strategic Network (WESNet, www.wesnet.ca). In this project, RADARSAT images are used to map wind speed in coastal regions. **Karem Chokmani** is one of the project's collaborators.

For more information

Beaucage, P., Bernier, M., Lafrance, G. & Choisnard, J. (2008). Regional mapping of the offshore wind resource: towards a significant contribution from space-borne synthetic aperture radars. *IEEE J. Selected Topics in Applied Earth Observations and Remote Sensing* (IEEE J-STARS) 1(1): 48-56.

http://dx.doi.org/10.1109/JSTARS.2008.2001760

Karem Chokmani recently initiated a research program with the objective of improving the quality of remote sensing estimates of the distribution and physical properties of snow cover. One of his projects aims at developing an approach to correct tropospheric effects on multi-date interferograms. Tunisian researchers are involved, and two sites in Tunisia threatened by desertification will serve to test the new approach by using radar interferometry to detect sand dune movements.

Alain N. Rousseau is working to improve hydrological numerical models. With his colleagues **Monique Bernier**, **André Saint-Hilaire**, **Yves Secretan**, and emeritus professor **Michel Slivitzky**, he has adapted the HYDROTEL model to the boreal context as part of a project of the Ouranos Consortium (Consortium on Regional Climatology and Adaptation to Climate Change, www.ouranos.ca).

Quebec's Ministry of Sustainable Development, Environment and Parks (MDDEP) hopes to apply HYDROTEL to the St. Lawrence watershed downstream from Lake Saint-Pierre. To this end, **Alain N. Rousseau** worked on adaptation of the GIS software PHYSITEL.

He is also involved in implementation of the GIBSI (*Gestion Intégrée des Bassins versants à l'aide d'un Système Informatisé*) model for Quebec City. This integrated economic-hydrologic modeling system will be used to develop a method for analysing contamination risks of potable water sources.

Alain N. Rousseau, **Claudio Paniconi**, and several collaborators continued their work on the Bras d'Henri hydrological basin (Chaudière-Appalaches region). This project, done in collaboration with Agriculture and Agri-Food Canada, seeks to improve the GIBSI model. They are also working to develop a similar numerical model adapted to the agricultural sector of Ontario in collaboration with Guelph University researchers.

Alain N. Rousseau and **Pierre Lafrance** continued their collaboration with Environment Canada in determining non-regulatory agri-environmental performance standards for pesticides in six Canadian watersheds. They also did a literature review on the relevance and applicability of organic farming as an alternative management practice in order to guide

future work related to standards determination for the agricultural sector.

Four researchers at the Centre, **Monique Bernier**, **Karem Chokmani**, **Alain N. Rousseau**, and **André Saint-Hilaire**, participate in phase II of AQUALYSE, a multidisciplinary project of the Ouranos Consortium. The project is led by a *Université Laval* researcher. The main objective is to analyse the hydrological processes occurring in highly "aqualysed" (*i.e.*, degraded by excess water) minerotrophic peat bogs in the La Grande River watershed. These peat bogs occupy a significant proportion of the land in Quebec's Middle North, where 50% of Quebec's electricity is produced. A better understanding of the hydrology of these environments will improve water supply forecasting for this region in the context of climate change.

Hydrodynamic monitoring of a highly aqualysed minerotrophic peat bog, Lake de Terre, James Bay

Jean-Pierre Villeneuve continued to work on applied mathematical models and optimal management of water resources. He also collaborated in preliminary work with the MDDEP aimed at developing a water conservation program.

Jean-Pierre Villeneuve, **Sophie Duchesne**, and other colleagues also work with the Vietnamese Academy of Science and Technology to transfer knowledge and implement integrated watershed management approaches to improve water quality in Vietnam.

• Statistical hydrology and climatology

Anne-Catherine Favre continued to work toward the integration of ensemble weather forecasting within short-term hydrological forecasts. She contributes to the Research Chair in Statistical Hydrology by modeling short-term water supply for simulations and forecasts, identifying and taking into account uncertainties in weather–water supply conceptual models, and analysing the impact of low frequency climatic variability on hydraulicity.

She collaborates with the Research Institute of Hydro-Québec on several projects. In one of these projects, she focuses on multivariate statistical modeling using copulas to determine variables such as peak flows. She also initiated a project within the Ouranos Consortium that seeks to evaluate and take into account uncertainties in precipitation and flows simulated by the Canadian Regional Climate Model.

Taha B.M.J. Ouarda is particularly interested in climatic and hydrological extremes. He developed a research program on local and regional estimates of extreme flows in order to adapt the design and operation of hydraulic structures to higher variability and climate change. In collaboration with Environment Canada, he studies the impact of climate change on hydrological extremes (floods, low water levels) using available high-resolution climatic scenarios.

In partnership with Hydro-Québec, he continues to improve the REGIONS software (for the regionalization of extreme hydrological events) by integrating the latest developments. He also continues to work on ARC QUEBEC, a software program for the regional analysis of floods in Quebec.

He is also continuing to explore the relationships between climate and mortality in collaboration with Quebec's National Institute of Public Health and the Ouranos Consortium. The current goal is to evaluate the impacts of extreme climatic events and to better take into account vulnerable populations.

In a previous phase of a project for the Canadian Coast Guard, he modeled squat, the additional sinkage caused by a ship's movement. He then developed an operational tool to estimate this parameter for use in shallow waterways such as the St. Lawrence River.

For more information

Beaulieu, C., Ghorbi, S., Ouarda, T.B.M.J. & Seidou, O. (2009). Statistical approach to model the deep draft ships' squat in the St. Lawrence waterway. *J. Waterw. Port C. Eng.* 135(3): 80–90.

http://dx.doi.org/10.1061/(ASCE)WW.1943-5460.0000003

Lastly, he contributes to the IPY Variability and Change in the Canadian Cryosphere project by using Bayesian methods to analyse current changes in the cryosphere.

An international collaboration

Canada-US partner – Partenaire canado-américain: **International Joint Commission – Commission mixte internationale** (www.ijc.org)

2009 is the 100th anniversary of the Boundary Waters Treaty, which sets the principles that guide Canada and the United States in managing the waters they share. The mission of the International Joint Commission is to assist the two countries in fulfilling the treaty's purpose. **Taha B.M.J. Ouarda** collaborates with researchers of this commission in the International Upper Great Lakes Study. In the first part of the study, changes in net basin components and explanatory variables (evaporation, runoff, inflow, temperature, precipitation, etc.) are analysed for the Great Lakes basin. In the second part, the atmospheric teleconnections are analysed using dependence models between climatic indices and hydrological variables in this area.

L'année 2009 marque le centième anniversaire du Traité relatif aux eaux limitrophes qui établit les principes permettant au Canada et aux États-Unis de gérer les cours d'eau qu'ils partagent. La Commission mixte internationale a pour mission d'aider les deux pays à atteindre les objectifs du traité. Taha B.M.J. Ouarda collabore avec des chercheurs de cette commission à l'*International Upper Great Lakes Study*. La première partie de l'étude vise à analyser les changements dans les composantes de l'apport en eau du bassin des Grands Lacs et les variables en cause (évaporation, écoulement, température, précipitations, etc.). La deuxième partie de l'étude s'attarde à analyser les téléconnections atmosphériques à l'aide de modèles reliant les indices climatiques aux variables hydrologiques dans cette région.

André Saint-Hilaire continues his work on statistical modeling of abiotic variables in aquatic environments. He seeks to develop water temperature models and methods for estimating suspended sediment concentrations and in-stream flow needs. This last parameter is of crucial importance in environmental impact assessments. Hence, Fisheries and Oceans Canada (DFO) has asked him to characterize rivers' natural regimes and do a comparative analysis of the indicators of hydrological alteration used to estimate in-stream flow needs in hydroelectric projects.

In collaboration with DFO researchers, he is also pursuing a hydrological and statistical evaluation of the design and effectiveness of the sediment retention basins used to mitigate the impacts of industrial peatland harvesting on aquatic habitats.

André Saint-Hilaire and **Taha B.M.J. Ouarda** work together on a number of research projects. They have begun a project for Environment Canada to evaluate the adequacy of the water quality measurement network for Lake Winnipeg. As part of an international collaboration with the ENSEMBLES project of the European Community, they work on developing probabilistic scenarios of regional changes in the variability and frequency of extreme climatic events. They also continue to work in collaboration with Hydro-Québec on the development of statistical tools to assist in the design of hydraulic structures.

• Urban hydrology

Sophie Duchesne continues to pursue her research program, begun last year, on the development of mathematical models applied to the management of water-related infrastructure. She is interested in modeling flow and water quality and in improving the management of municipal water infrastructure. In the latter area, she focuses on improving models used to estimate the current state of water and sewage lines. She has started such a project for Quebec City in collaboration with **Alain Mailhot** and **Jean-Pierre Villeneuve**.

Alain Mailhot's work is also related to hydrology and water infrastructure in urban environments. For example, he examines possible ways for Canadian cities to adapt their management of underground and drainage infrastructure to anticipated climate change.

One such project is currently underway in Montreal. **Alain Mailhot** and **Sophie Duchesne** are evaluating different adaptation strategies for maintaining the functionality of drainage infrastructure in the face of predicted increase in extreme precipitation events associated with climate change. They also analyze implementation conditions of the different strategies considered.

For more information

Dridi, L., Parizeau, M., Mailhot, A. & Villeneuve, J.P. (2008). Using evolutionary optimization techniques for scheduling water pipe renewal considering a short planning horizon. *Comput. Aided Civil. Infra. Eng.* 23: 625-635.

http://dx.doi.org/10.1111/j.1467-8667.2008.00564.x

• Environmental hydraulics

Normand E. Bergeron is particularly interested in fish habitats. He continues to work on improving knowledge about river shapes and processes that affect the winter habitat of salmon.

He also focuses on monitoring fish movements. He conducted a critical review of the different technologies used to monitor fish in hydroelectric projects for the Research Institute of Hydro-Québec. For Fisheries and Oceans Canada, he evaluated the effectiveness of a fish ladder on Prince Edward Island.

He is involved in the Geosalar II multidisciplinary project of the GEOIDE Network. His research team uses PIT-tag (Passive Integrated Transponder) technology to monitor daily movements of juvenile Atlantic salmon in fluvial environments. The goal of this project is to understand how habitat structure influences salmon movements, growth, and survival.

He is also doing field work in support of a project to measure river ice thickness using georadar. Financed by the Research Institute of Hydro-Québec, this project explores the possibility of analysing multiple echo pulses to determine the thickness of thin ice cover, which cannot be done with georadar at present.

Lastly, **Normand E. Bergeron** initiated a project with **Patrice Couture** that evaluates the impact of an invasive alga (*Didymosphenia geminata*) on the number of juvenile salmon. This alga can modify salmon habitats and their food abundance.

André Saint-Hilaire and **Normand E. Bergeron** collaborate with McGill University and Canadian Rivers Institute (UNB) researchers on a project of the Ouranos Consortium to learn more about the role that thermal refugia play within salmon ecology in the context of global warming.

For more information

Guillemette, N., St-Hilaire, A., Ouarda, T.B.M.J., Bergeron, N., Robichaud, E. & Bilodeau, L. (2009). Feasibility study of a geostatistical modelling of monthly maximum stream temperatures in a multivariate space. *J. Hydrol.* 364: 1-12.

http://dx.doi.org/10.1016/j.jhydrol.2008.10.002

Yves Secretan and **Normand E. Bergeron** are both associated researchers in another project of the Ouranos Consortium. This project is designed to model the response of St. Lawrence tributaries to environmental changes. The goal is to broaden the hydrosedimentary modeling approach used in a previous phase to obtain a more complete overview of potential impacts.

Yves Secretan continued to offer technical support for the MODELEUR hydrodynamic simulation software developed at the INRS by the research group in numerical ecohydraulics. In addition, he worked on new developments of the H2D2 software, in partnership with Environment Canada, in order to allow modeling of the St. Lawrence River between Trois-Rivières and Quebec City.

An international collaboration

Brazilian partners – Parceiros brasileiros:
Instituto de Estudos Superiores da Amazônia
(IESAM, www2.iesam-pa.edu.br)
Universidade Federal do Pará
(UFPA, www.portal.ufpa.br)

The INRS and its scientific partners in Brazil are collaborating on development of a numerical model for the Bay of Guajará, which borders the town of Belém in the state of Pará, in northeastern Brazil. The model will be used to analyse the current dynamics in this bay subjected to tidal variations at the junction of the Guamá and Acará rivers. It will also enable analysis of the diffusion and transport of various pollutants, mainly hydrocarbons and Belém wastewater. Finally, the model will assist in decision-making for environmental impact assessments. The project will draw on the MODELEUR and H2D2 software developed at the *Centre Eau Terre Environnement* and **Yves Secretan**'s expertise to train Brazilian researchers.

A colaboração entre o *Institut national de la recherche scientifique* (INRS) e seus parceiros científicos no Brasil visa construir um modelo numérico para a bacia hidrográfica de Guajará, que banha a cidade de Belém, no Estado do Pará, norte do Brasil. O modelo permitirá analisar a dinâmica das correntes na bacia, na confluência dos rios Guamá e Acará, que está submetida à influência da maré bem como ao transporte-difusão de diversos poluentes (principalmente hidrocarbonetos e efluentes da cidade de Belém). O modelo servirá igualmente como ferramenta de apoio na gestão de estudos de impactos ambientais. Os softwares Modeleur e H2D2, desenvolvidos no *Centre Eau Terre Environnement* pelo grupo de pesquisa em Ecohidráulica numérica serão colocados à disposição e, aliados à experiência de Yves Secretan, auxiliarão na formação de pesquisadores brasileiros.

Translation: Rodrigo Passos

• Oceanography

Yves Gratton continues his work to determine the extent to which mid-scale physical processes affect oceanic biological productivity. He is also actively contributing to a research group that seeks to develop a unique physical-biological model for the Canadian Arctic Archipelago that integrates ice cover and biogenic carbon fluxes.

He is also involved in two IPY projects. He leads the research group on physical oceanography within the Circumpolar Flaw Lead System Study (www.ipy-cfl.ca), which focuses on a circumpolar polynya system. He is also one of the main researchers of the Canadian Arctic SOLAS Network (www.quebec-ocean.ulaval.ca/C-SOLAS) which seeks to reduce uncertainties regarding the interactions between sea ice, oceanic circulation, and gas and particle emissions in the Arctic.

As part of phase II of the ArcticNet Network research program, he leads the Long-Term Observatories in Canadian Arctic Waters project. In this project, changes in the physical, biological, and geochemical properties of the ocean are studied with the help of a network of measuring stations distributed across the Arctic. He specifically focuses on marine biodiversity hot spots in order to understand their roles within the ecosystem and their sensitivity to climate change.

For more information

Tremblay, J.E., Simpson, K., Martin, J., Miller, L., Gratton, Y., Barber, D. & Price, N.M. (2008). Vertical stability and the annual dynamics of nutrients and chlorophyll fluorescence in the coastal, southeast Beaufort sea. *J. Geophys. Res. – Oceans* 113: C07S90.

http://dx.doi.org/10.1029/2007JC004547

Ongoing waste decontamination and reclamation research

Waste needs to be managed as a resource if the sustainable use of natural resources is to be attained. Cities and industries face major challenges with respect to waste recycling and reuse, and thus methods and technologies used have to be adapted continuously. The INRS is a leader in the development of environmental technologies. *Centre Eau Terre Environnement* researchers possess unique expertise in the development of treatment and reclamation technologies of contaminated sewage sludge, effluents, and solid waste. Moreover, the Centre has one of the

most complete and flexible pools of pilot equipment and analytical instruments in Canada for research and development projects. New technologies conceived at the Centre are regularly patented and transferred to industry.

The Centre's waste decontamination and reclamation research is focused on environmental technologies. Work is aimed at extracting metals from waste (hydrometallurgy and environmental mineral processing), treating liquid and solid waste (urban and industrial decontamination), and producing value-added products (biomass and waste reclamation).

• Hydrometallurgy and environmental mineral processing

Mario Bergeron's research team has developed restoration processes for metal- and oil-contaminated soils and sediments. Cell and column flotation techniques were tested successfully on contaminated solids.

Jean-François Blais focuses some of his work on the treatment of solids contaminated by toxic metals. He is developing a predictive and comparative model of the different treatment technologies for metal-contaminated effluents. He is also interested in contamination by rare metals (Be, Mo, Sb, Sn, Ti).

Guy Mercier works on the treatment and reclamation of solids contaminated by toxic metals and PAH (Polycyclic Aromatic Hydrocarbons). He is developing technologies for extracting and recovering useful metals. He specifically focuses on red mud, chrysotile residues, contaminated soils, and rifle range backstop soils.

Jean-François Blais, **Guy Mercier** and **Patrick Drogui** closely collaborate on several projects in industrial partnerships. **Rajeshwar Dayal Tyagi** participated in one of these projects, done in partnership with the company Filter Innovations. In this project they developed and tested new electrolytic treatments for industrial and municipal effluents contaminated by toxic metals and organic and inorganic pollutants.

In partnership with the company Tecosol, these researchers are completing the development of an innovative process that combines in a single step the extraction of metals (by chemical leaching) and of PAH by using a new type of surfactant. They are also exploring the applicability of this new technology to other types of organic contaminants.

Lastly, this same research team has developed a new decontamination process for chromated copper arsenate–treated wood. In collaboration with a University of Toronto researcher, they are presently testing this process of metal extraction from wood at a pre-industrial pilot scale in the INRS laboratories.

For more information

Jafari, A., Zawiska, F., Drogui, P., Blais, J.F. & Mercier, G. (2009). Selective recovery of metals in leachate from chromated copper arsenate treated wastes using electrochemical technology and chemical precipitation. *Hydrometallurgy* 96(4): 315-326.

http://dx.doi.org/10.1016/j.hydromet.2008.12.002

• Urban and industrial decontamination

The INRS environmental decontamination research group, **Jean-François Blais**, **Mario Bergeron**, **Patrick Drogui**, **Guy Mercier** and **Rajeshwar Dayal Tyagi**, continued to work on coupling ultrasound technology with the processes they have developed to stabilize and treat sewage sludge.

For more information

Tremblay, J., Blais, J.F., Drogui, P. & Mercier, G. (2008). Stockage et stabilité à long terme de boues d'épuration municipales décontaminées et stabilisées par voie chimique ou biologique. *J. Environ. Eng. Sci.* 7(4): 357-368.

http://dx.doi.org/10.1139/S08-013

Guy Mercier and **Jean-François Blais** in collaboration with **Patrick Drogui**, are working on an improved version of the LISOX Separator treatment process for pig manure in partnership with the marketing corporation. They are also assessing greenhouse gas emissions during the process in order to minimize this effect.

Patrick Drogui's research interests relate to the development of electrotechnologies for the removal of endocrine-disrupting chemicals and other organic and inorganic pollutants from wastewater. He is presently working on a new electrotechnology to produce oxydant oxygen species to decontaminate effluents without adding any reactant. Another advantage of this cleaner technology is that it is easily automated.

The transfer of these new electrotechnologies to industry is underway. Discussions are ongoing with the company Filter Innovations concerning a marketing licence for industrial development of an electrolytic process (EC-EF process) to treat municipal and industrial effluents by *in situ* production of a coagulant/flocculant agent. Large-scale tests are currently being done in a wastewater treatment plant to demonstrate the performance of the EC-EF process.

He is also involved in several other industrial partnerships. One of these, financed by Gecko Alliance Group, seeks to analyse technological risks associated with the use of electrobromation cells to treat spa water. In another partnership, with Premier Tech, he is conducting an evaluation of an electrocoagulation process that removes phosphate from residential septic system effluents. Lastly, he continues to collaborate with Quebec's Industrial Research Centre (CRIQ) on membrane bioreactor research.

Rajeshwar Dayal Tyagi carried out a prefeasibility study for a thermal pretreatment of sludge that would decrease the amount of secondary sludge produced at the Victoriaville wastewater treatment plant. He also performed an evaluation of greenhouse gas emissions during sewage sludge disposal, treatment, and reclamation in the Greater Moncton area.

Microscopic photograph of fungal mycelium used in sewage sludge bioflocculation

• Biomass and waste reclamation

Mario Bergeron's research team continued the development of a new production process for chlorosilanes (especially $SiCl_4$). These chemical compounds are the base material used by the optical fibre, solar panel, and semiconductor industries. The team works on improving the chemical processes involved in chlorosilane production and also develops the necessary manufacturing equipment at the laboratory and pilot scales. The technology could also be used to recycle optical fibre and glass residues.

Jean-François Blais, **Guy Mercier**, and **Patrick Drogui** completed their evaluation of the potential for using an organic by-product (cocoa scales) to filtrate the effluents of a Biscuits Leclerc factory. They also looked at ways to use the sludge produced at the company treatment plant to produce high-quality composts.

Waste reuse was also the objective behind **Guy Mercier** and **Jean-François Blais**'s study of the energy production potential of various sludge and waste materials that could be burned in biomass boilers.

They also continued to collaborate with researchers of the INPL French Research Institute on phytoremediation of contaminated soils. Specifically, they seek to produce nickel for industrial use from metal-accumulating plants used to decontaminate sites polluted by nickel.

Satinder Kaur Brar has just started two research projects aimed at producing value-added products from wastewater and sewage sludge. In the first one, she focuses on the fate of toxic organic compounds during decontamination and reclamation processes in wastewater treatment plants. In the second, she is developing commercial formulations of the biopesticide Bt (*Bacillus thuringiensis*) from residual materials. The goal is to obtain a product that is economical, stable, easy to use, and above all, effective.

Several of **Rajeshwar Dayal Tyagi**'s research projects relate to the decontamination of sewage sludge and its use to produce value-added products. In partnership with industry, this researcher is developing a biopesticide based on *Cydia pomonella* (a major pest of apple orchards). The goal is to obtain a viral insecticide in powder form.

Satinder Kaur Brar collaborates on a number of **Rajeshwar Dayal Tyagi**'s projects. In one project, done in partnership with industry, they seek to produce an effective and economic bio-inoculant from wastewater and sewage sludge using *Rhizobium* (a nitrogen-

fixing soil bacteria). In another project, financed by an agroalimentary research and development program, they are working toward the production of biofertilizers–biopesticides from the same residual materials using *Rhizobium* and *Trichoderma* (a soil fungi). They want to develop a robust and effective formulation to inoculate seeds or soil.

These two researchers also studied the formulation of biopesticides produced by Quebec's Agency of Forest Protection against Insects and Diseases (SOPFIM) in order to improve the biopesticides' stability and effectiveness.

For more information

Vu, K.D., Tyagi, R.D., Brar, S.K., Valero, J.R. & Surampalli, R.Y. (2009). Starch industry wastewater for production of biopesticides - ramifications of solids concentrations. *Environ. Technol.* 30(4): 393-405.

http://dx.doi.org/10.1080/09593330902753495

An international collaboration

US partner:
United States Environmental Protection Agency
(EPA, www.epa.gov)

Rajeshwar Dayal Tyagi, in collaboration with **Satinder Kaur Brar** is carrying out a scientific project in partnership with Rao Y. Surampalli of the EPA. This Canada–US collaboration profits from the expertise of INRS researchers in the field of industrial and municipal waste reclamation for biopesticide production. The biopesticides are destined to be used in the US for protecting forests and agricultural lands from insect pests. In the end, biotechnological processes will be implemented both at the laboratory and industrial levels. The project's benefits are threefold: a) a significant contribution to sustainable waste management, b) the production of alternative biopesticides, and c) a reduction in greenhouse gas emissions by reusing the carbon contained in waste.

Ongoing biogeochemistry and contamination issues research

The pollution of aquatic environments by toxic substances is a major problem to which society must respond. These pollutants enter aquatic ecosystems from point (*e.g.* spills) and diffuse (*e.g.* agriculture) sources, accumulate in sediments, and concentrate up the food chain. A good knowledge of the processes controlling the exchange of toxic substances between sediments, the water column, and organisms (plants, insects, fish, etc.) and the effects of these substances on ecosystems is essential to remediate the problem. The *Centre Eau Terre Environnement* biogeochemistry research group makes a unique contribution to remediation efforts through its capacity to combine research on contaminant dispersion in the environment, the assimilation and effects of trace metals on aquatic organisms, and detection of environmental changes in aquatic ecosystems by using certain organisms as sentinels.

Research in biogeochemistry focuses on contaminant dispersion in aquatic environments (environmental geochemistry), bioaccumulation of trace metals and their effects on aquatic organisms (ecotoxicology), and microbial productivity and carbon fluxes in freshwater ecosystems (limnology).

• Environmental geochemistry

Peter G.C. Campbell conducted a geochemical characterization of lake sediments contaminated by metals for the mining company QIT. The work was done in collaboration with the Mining and Mineral Sciences Laboratory of Natural Resources Canada.

In collaboration with Quebec's Ministry of Natural Resources and Wildlife, **Claude Fortin** and **Alain N. Rousseau** completed a second year of monitoring of the impacts of forest harvesting on the chemical composition and hydrological regime of alkaline lakes in the Chics-Chocs Wildlife Reserve (Gaspésie region).

Charles Gobeil's research interests relate to the geochemistry of trace elements in lake and marine sediments. He analyzes sediments and interstitial water in order to reveal the contemporary biogeochemical cycles of metallic contaminants.

He is the leader of the Canadian IPY project The Carbon Cycle in the Canadian Arctic and Sub-Arctic Continental Margin. The project's goal is to increase knowledge on the interactions between climate change and element cycles in the Arctic Ocean.

Pierre Lafrance's research program focuses on the influence of biophysico-chemical processes on the evolution and transport of pesticides in surface and groundwater. The ultimate goal is to prevent environmental impacts associated with water pollution.

For more information

Poissant, L., Beauvais, C., Lafrance, P. & Deblois, C. (2008). Pesticides in fluvial wetlands catchments under intensive agricultural activities. *Sci. Total Environ.* 404(1): 182-195.

http://dx.doi.org/10.1016/j.scitotenv.2008.05.030

On the terrestrial side, **Marc Richer-LaFlèche** continued to study heavy metal contamination in forest ecosystems of the York River valley (Gaspésie region).

• Ecotoxicology

Peter G.C. Campbell continued his research on the relationships between metal speciations and their biological effects. He is developing a model to predict the bioavailability of trace metals in aquatic organisms. He continues to collaborate with **Claude Fortin** on this subject; together, they are working to determine metal speciation in natural environments from the biological responses of algae.

Peter G.C. Campbell's expertise in aquatic geochemistry and ecotoxicity was requested by the government of the Southern Province of New Caledonia. He took part in a second expert evaluation of the environmental risks related to effluent discharge into a marine lagoon by a hydrometallurgic treatment plant for cobalt and nickel ore.

Patrice Couture's research program examines the mechanisms of metal toxicity in wild fish, particularly in yellow perch. **Peter G.C. Campbell** collaborates with this researcher on several projects in partnership with the mining industry. In collaboration with a *Université Laval* researcher, they are developing functional genomic tools to measure the response of yellow perch to stresses caused by metal contamination. Yellow perch sampled in lakes of the Rouyn-Noranda and Sudbury regions are used to develop one of those tools: a DNA microarray (DNA fragments fixed on a miniature support).

Paul Drevnick is a new professor-researcher at the INRS. He specializes in the biogeochemistry of contaminants in aquatic ecosystems. He recently started a research program on mercury methylation to understand its effects on fish in natural environments.

Claude Fortin has just started a new phase of his research to improve prediction models for the bioavailability of trace elements in aquatic environments. Simple models already exist, but certain aspects must be further studied before these models can be applied practically.

In collaboration with Rio Tinto Alcan, this researcher studies the capacity of green algae to accumulate and adsorb aluminium and fluoride. The role of pH is also examined.

One of the main objectives of **Landis Hare**'s research activities is to develop reliable models to predict metal concentrations and their effects on aquatic organisms.

Government studies have shown that the sediments of some lakes in the Chibougamau area are contaminated by metals (arsenic, copper, nickel, and zinc). The government asked him to measure metal

Maikel Rosabal Rodriguez and Julien Lachanté sampling water, D'Alembert Lake, Rouyn-Noranda

concentrations in sediments and benthic invertebrates in order to estimate the metals' bioavailability and their accumulation in the food chain.

Several researchers at the Centre contribute to the MITHE (Metals in the Human Environment, www.mithe-sn.org) Strategic Network. **Peter G.C. Campbell** is the co-leader of the aquatic ecosystems research theme. Within this theme, **Landis Hare** leads a project on the transfer of trace metals within aquatic food chains. **Peter G.C. Campbell**, **Patrice Couture**, and **Claude Fortin** are also involved in this study, which looks at the processes driving the transfer of metals (Cd, Ni, Se, and Tl) toward higher trophic levels. **Claude Fortin** also examined cadmium speciation in aqueous media of cell cultures. **Patrice Couture** and his team collaborate on another project of this network, in which copper effects on tissue-specific gene expression patterns and physiological changes are studied in fathead minnows.

For more information

Kraemer, L.D., Campbell, P.G.C. & Hare, L. (2008). Modeling cadmium accumulation in indigenous yellow perch (*Perca flavescens*). *Can. J. Fish. Aquat. Sci./J. Can. Sci. Halieut. Aquat.* 65(8): 1623-1634.

http://dx.doi.org/10.1139/F08-081

• Limnology

Isabelle Laurion specializes in aquatic ecology, bio-optics, and ecophysiology. She participates in a limnological study of Lake Saint-Charles and its watershed that seeks to determine the causes of the cyanobacterial blooms observed in the lake since 2006.

The main objective of her current research activities is to evaluate the consequences of permafrost melting on carbon fluxes in northern environments. She examines thermal and light regimes in northern aquatic ecosystems and evaluates their influence on microbial productivity and gas exchanges. She contributes on this subject to two IPY projects, MERGE-Canada (Arctic Microbial Ecosystems, www.cen.ulaval.ca/merge/) and CICAT (Climate change Impacts on Canadian Arctic Tundra ecosystems, ipytundra.ca), and to the ArcticNet project Freshwater Resources of the Eastern Canadian Arctic, which is part of phase II of this network's research program.

She also collaborates on the international Ecosensor project (www.ecosensor.org), which involves researchers from several countries (Argentina, Austria, Canada, Spain, and Slovenia). The objective is to use isolated lakes as sentinels for climate change and models to determine the biogeographic patterns of microbial organisms.

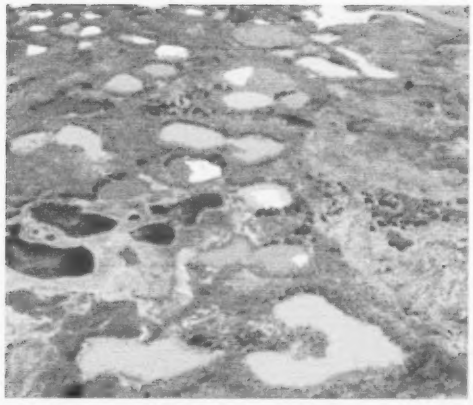
Northern research

Canadian partner:
Centre d'études nordiques
(CEN, www.cen.ulaval.ca)

Thermokarst ponds are depressions in the ground filled with water and created by seasonal melting of the soil in Arctic and Subarctic ecosystems. Permafrost melting caused by global warming amplifies this phenomenon. **Isabelle Laurion** is interested in the microbial diversity of these ponds, the factors that influence their microbial activity, and their greenhouse gas emissions (GHGs: CO_2 and CH_4). She seeks to evaluate the contribution of these ponds to the carbon fluxes of northern ecosystems. **Isabelle Laurion** and **Pierre Francus** are part of a research group of the CEN working to define a correlation between the ponds' water colour (which depends on organic material and particle contents) and their GHG emissions. Such a correlation would allow the use of remote sensing to estimate ponds' GHG emissions over vast areas. They are also analyzing the history of the ponds' formation and their lifespan. The study sites are located in Nunavik and Nunavut.

ᑕᐃᖅᑑᓗᓪ ᖃᖅᓄᓚᑎᑐᑦ (Thermokarst ponds) ᑕᓯᐅᓯ/ᐃᑎᖅᓴᐃᓪ ᓄᓇᒥ ᐃᒪᖃᑦᑑᑦ ᑲᒪ ᐃᒪᒪᑕᑦᑕᑐᑦ ᐊᑕᐅᓪᓚᖅᓴᓪ ᓄᓇᐃᑦᑎᐊᑕᐃᓪᓕᕐᕋᐃᑦ ᑭᑭᖅᑕᑎ ᑲᒪ ᓂᓪᓴᓪ ᐊᑦᓂᓕᕐᓂᖅ, Subarctic ᓄᓇᑎᓂ, ᓄᓇᑕᐃᑦ ᐃᑭᐊᖅᒪ ᐋᖅᑯᓂᖅ ᓂᕆᑎᑐᑦ ᐊᑕᖅᖃᑕᑦᓂᐊᖃᑕᑎᒪᒻᒪ ᓂᓪᓴᓪᓕ ᑲᓇᖅᑐᑦ ᑕᓯᐅᓯᓪᓚᖅᓴᓪ. ᐃᓵᐱᐊᖅᒪ ᓯᑕᖅᑭᓪ, Isabelle Laurion ᐃᖅᐱᒥᓴᖅᑰᒪᑦ ᐊᖅᑭᑎᓴᒋᐊᖅᑎᓂᓕᖅᓂᖅᓂᖅ ᑕᓯᐊᑭᐅᐃᑦ, ᓂᓇᓂᖅ ᐊᖅᑕᐊᔪᑎᑎᓴᒍᒪᒻᒪᓕᒃᑕ ᑕᓯᐊᑭᖅᓂ ᐃᒪᐃᑦ ᑲᒪ ᓂᓇᓂᖅ ᓂᓪᓴᓪ ᐃᓯᑕᑎᑕᐅᐊᖅᒪᓕᒃᑕ (GHGs: CO2 and CH4). ᖃᐅᔨᓴᕈᒪᓕᕐᓂᖅ ᑕᓯᐊᑭᓂᖅ ᓂᓇᓂᖅ ᐅᐊᕈᑦᑕᖅᒪᒻᒪᓕᒃᑕ ᐊᑦᑎᓴᓕᓂᖅ, ᐃᓵᐱᐊᓯ ᓯᑕᖅᑭᓪ, Isabelle Laurion ᑲᒪ ᐱᐅᖅ ᑐᕐᖃᖅᖃᖅ, Pierre Francus ᐱᓯᓂᖃᑕᐅᓕᕐᓂ CEF ᖃᐅᔨᓴᑐᓂᓪ, ᓯᓚᐃᓵᒪᓕᓂᕐᓂᓂᑎᑎᓪᓂᖅ ᑕᓯᐊᕈᐃᑦ ᖃᓄᖅᑎᑎᒍᑦ (ᐊᓐᑐᐊᓂᖃᒪᑕ ᓂᓇᓂᖅ ᐅᐊᕈᑎᑎᖃᓂᖅᓂᓪᓂᑦ) ᑲᒪ GHG,ᖃᓂᖅᒪᓂᖅ, ᓂᐊᒪᑕᓂᑕᐊᓂᓂᖅ, ᑕᒪᓂᐊ ᐃᓗᐊᓂᑐᑦ ᖃᑎᑎᓂᓂᓕᓂᖅ ᖃᐅᔨᓴᑕᐅᓂᖅᑕᑦ ᐊᑐᐅᑕᒪᓕᖅᒪᑕ ᓂᕆᑎᑐᓂᖅ GHG,ᓂᓂᓂᓂᖅᒪᑕᓂᑕᐊᓂᓂᖅ, ᑲᒪ ᑕᓂᐊᐊ ᐱᓇᓂᖃᑎᑐᑦ ᖃᖅᑐᖅᓴᖅᑕᑦ ᑕᓯᐊᑭᐅᓂᖅᓂᓪᓂᖅ ᑲᒪ ᖃᓄᖅ ᐊᐅᓂᑎᑎᓂᖅ ᓴᓇᐊᑕᓂᓂᖅᓂᓪᓂᖅ, ᖃᖅᑐᖅᓴᖅᑎᐅᓂᖅ ᓄᓇᐃᑦᑎᐊᑕᐃᓪᓕᕐᕋᐃᑦ ᑲᒪ ᓄᓇᐃᑦᑎᐊᑕᐃᓪᓕᕐᓂᖅ.

Translation: Martha Flaherty



Thermokarst ponds, Umiujaq area, subarctic Quebec.

Ongoing geological sciences research

Geoscience research addresses several of the most important socio-economic issues that society must currently face. The increasing demand for natural resources, the need for sustainable management of groundwater resources, the risks posed by natural hazards related to geological processes, and the impacts of climate change are all crucial issues for researchers in geological sciences. The *Centre Eau Terre Environnement* and the Quebec division of the Geological Survey of Canada (GSC) are partners within a scientific collaboration agreement between the INRS and Natural Resources Canada. This university–government partnership has created the most important multidisciplinary research group in geosciences in Canada: *Centre géoscientifique de Québec* (CGQ).

Geoscience research is highly diversified at the CGQ. The joint objective is to develop efficient analytical methods for different geological environments in order to understand their association with fossil fuels and minerals (geological environments and natural resources). Environmental geoscience activities are also important. They relate to the management and contamination issues associated with groundwater (hydrogeology), to current geological processes (environmental geology), and to reconstruction of past environments using biological indicators (paleoenvironmental studies). Geophysical applications are also of interest, for example in archaeology.

• Geological environments and natural resources

In partnership with the company Vale Inco, **Erwan Gloaguen** seeks to improve 3D geological models of ore contents by integrating seismic data.

The research interests of **Lyal Harris**'s team relate to the tectonic regimes of geological structures such as folds and shear zones and to their formation mechanisms. They also work on the processing and structural and tectonic interpretation of geophysical data. Their research finds applications in mineral and oil exploration.

In the laboratory, centrifugal modeling of channel flow tectonic processes has led to a better understanding of the formation of orogenic structures such as the Himalayas and enabled the formulation of a new hypothesis explaining the progressive development of typical structures in the granite and Archean greenstone belts.

Lyal Harris has also been looking at new approaches for processing aeromagnetic and gravimetric data as part of the Abitibi Project of the TGI-3 (3rd Targeted Geoscience Initiative, sst.rncan.gc.ca/tgi/abitibi_e.php), led by **Benoît Dubé** (GSC). One result has been the production of interpretative structural maps for the Chibougamau area in collaboration with **Jean H. Bédard** (GSC).

Lyal Harris's research team analyses the structural evolution and controls of mineralization in the Grenville Province in Quebec. In partnership with Laurentian Goldfields Ltd., they have completed the processing and interpretation of geophysical data for part of this province and started to look at other Archean and Proterozoic regions of Canada.

They also carried out a structural and metallogenic interpretation of Proterozoic rocks in northeastern Quebec and northern Labrador. Finally, in a project financed by the company Junex, they are working on a structural interpretation of aeromagnetic and gravimetric data of the shelf and external part of the Appalachian Mountains south of Quebec City.

Michel Malo continued his examination of potential fossil fuel reservoirs and ore deposits using a model of paleofluid circulation at the scale of orogenic fronts of mountain ranges.

For more information

Malo, M., Ruffet, G., Pincivy, A. & Tremblay, A. (2008). $A^{40}Ar/^{39}Ar$ study of oceanic and continental deformation processes during an oblique collision: Taconian orogeny in the Quebec reentrant of the Canadian Appalachians. *Tectonics* 27: TC4001.

http://dx.doi.org/10.1029/2006TC002094

He collaborates with GSC researchers and industrial partners on a number of projects. He continued to work with **Denis Lavoie** (GSC) to increase knowledge on bedrock potential and thermal maturation in the Bas-Saint-Laurent region. In partnership with Opinaca Mines and in collaboration with **Benoît Dubé** and **Léopold Nadeau** (both from GSC), he is studying the Roberto gold deposit (James Bay region) in order to obtain a metallogenetic model for the area.

Last year, **Michel Malo** initiated a project in partnership with researchers of the Geological Survey of Canada, the company Pétrolia, and the French Oil Research Institute. The long-term objective of this project is to develop a model for the evolution of the oil system in the Gaspésie region in order to better understand the structure of fossil fuel reservoirs. He also carried out a synthesis of current knowledge on the oil system of the Matapédia area of the same region for the company Gastem.

Michel Malo is the co-director of the DIVEX (DIVersification of mineral EXploration in Quebec, www.divex.ca) Network. He also leads the network's project on the Lake Ell mineral intrusion (James Bay region) with GSC collaborators **Benoît Dubé** and **Valérie Bécu**. They are working to determine the age, nature, and characteristics of the copper–gold–silver mineralization contained in this intrusion. Several other researchers at the Centre are also involved in this network. **Lyal Harris**'s team continued their study of the geophysical and structural controls of mineralization and of the petrology and geochemistry of mineralization and alteration zones in the southwestern part of Grenville Province in collaboration with **Louise Corriveau** (GSC) and **Marc Richer-LaFlèche**.

Marc Richer-LaFlèche has several research activities financed by JAG Mines Ltd. and Ressources & Énergie Squatex Inc. underway to determine the fossil fuel potential of sedimentary formations in different regions of Quebec. In the Charlevoix region, he completed a lithogeochemical study of Paleozoic rocks of the Baie-Saint-Paul and La Malbaie area as well as magnetometric, electromagnetic, and gravimetric surveys. He completed his geochemical study of forest soils in Témiscouata (Bas-Saint-Laurent region) and initiated a regional gravimetric analysis and radiometry surveys (U, Th, and K). He also continued his geochemical and geophysical study of limestones and bituminous shales of the Lake Saint-Jean basin. Finally, he started a new project that includes gravimetric and magnetometric surveys conducted on the frozen surface of Lake Saint-Jean in winter.

Édith Chouinard, microgravimetric survey, Lake Saint-Jean

He is also interested in minerals. For Exploration Orbite V.S.P.A. Inc., he supervised a structural study of rock outcrops and drill cores of aluminous argilites, which can be used to produce industrial minerals, in Grande-Vallée (Gaspésie region).

Pierre-Simon Ross's research activities relate to ore deposits associated with volcanic or magmatic activity such as volcanogenic massive sulphide deposits (Cu, Zn, Au, Ag), porphyries (Cu, Mo, W, Au), and kimberlites (diamonds) and their geological environments.

Three studies are underway in the Abitibi subprovince (Quebec and Ontario) in relation to volcanogenic massive sulphide deposits. One, in the Matagami area, seeks to reconstruct volcanic architecture at two scales, the deposit and the region. This multidisciplinary study is part of the DIVEX Network and involves three universities (*École Polytechnique*, UQAC, and INRS). The project's partners are the GSC (through the TGI-3 Abitibi Project), Quebec's

Ministry of Natural Resources and Wildlife (MRNF), CONSOREM (Research Consortium on Mineral Exploration), and the companies Xstrata Zinc, SOQUEM, Ressources Breakwater, and Donner Metals Ltd.

The two other studies on volcanogenic massive sulphide deposits take place in the Blake River group, near Rouyn-Noranda. The first of these, a volcanologic, geochemical, and metallogenic characterization of a portion of the Hébécourt formation, is being done in collaboration with the MRNF and the company Ressources Cogitore. The second study, financed by the GSC, focuses on characterizing the mafic to intermediary volcanoclastic units of the entire Blake River group to determine its origin and stratigraphic position in order to contribute to the reconstruction of Archean underwater volcanism.

• Hydrogeology

Bernard Giroux is a new professor-researcher at the INRS. His research interests relate to the development of geophysical tools for aquifer characterization. The possible applications are numerous, but recently he has focused in particular on carbon sequestration.

The goal of **Erwan Gloaguen**'s research program is to increase knowledge on the hydrogeological properties of regional and subregional aquifers by using geostatistical approaches to integrate *in situ* geophysical and hydrogeological data. He is also developing innovative methods to interpret and analyse borehole geophysical data in order to obtain high-resolution hydrogeological local-scale models. The knowledge acquired will help to protect, characterize, and restore aquifers.

Within **Michel Malo**'s new Research Chair on Geological Sequestration of CO_2, **Erwan Gloaguen** works on geological simulations of potential reservoirs' reactions to CO_2 injection.

René Lefebvre continued to develop hydrogeological methods of aquifer characterization in order to better define their heterogeneity. He and **Erwan Gloaguen** applied these methods in the field to conduct a hydrogeophysical characterization of the old landfill site of Saint-Lambert-de-Lauzon (Chaudière-Appalaches region). This characterization was then integrated with geostatistical data to define flow conditions and leachate migration.

René Lefebvre also continued to work on a synthesis of the hydrogeological conditions of the zone encompassing Valcartier and Val-Bélair in relation to TCE (trichloroethylene) contamination of groundwater.

He is also interested in groundwater resources. He takes part in an SNC-Lavalin project financed by the Canadian International Development Agency involving a hydrogeological synthesis of groundwater resources in northern Ghana. One goal of the project is to contribute to building the capacity of local organizations to manage these resources.

An important project financed by Quebec's Ministry of Sustainable Development, Environment and Parks was initiated this year. The project's collaborators are the Geological Survey of Canada (GSC), Quebec's Agroenvironment Research and Development Institute, the Watershed Management Committee of the Yamaska River, the *Université Laval*, and regional organizations. The goal is to obtain a precise description of the groundwater resources of the Montérégie-Est region. The project is coordinated by **René Lefebvre** at the INRS in collaboration with his colleagues **Erwan Gloaguen, Richard Martel** and **Claudio Paniconi**. GSC collaborators are **Christine Rivard** (coordinator) and **Michel Parent**. An inter-institutional research group on groundwater supervises similar projects in five regions of Quebec.

Richard Martel's research interests relate to groundwater contamination caused by military explosives and propellants. He is developing a numerical prediction model for explosive residue concentrations in the groundwater of Canadian military training areas. He is also analysing the evolution in the environment of different energetic materials in collaboration with Defence Research and Development Canada.

Richard Martel and **René Lefebvre** are working on a new technology of *in situ* restoration for oil-contaminated aquifers in partnership with the company TechnoRem. The method combines soil washing, vacuum extraction, and chemical oxidation. Their aim is to apply this new technology at the scale of a contaminated site.

For more information

Bernardez, L.A., Therien, R., Lefebvre, R. & Martel, R. (2009). Simulating the injection of micellar solutions to recover diesel in a sand column. *J. Contam. Hydrol.* 103: 99-108.

http://dx.doi.org/10.1016/j.jconhyd.2008.09.009

An international collaboration

Mexican partner – Con la colaboración en México:
Centro Interamericano de Recursos del Agua
(CIRA, www.cira.uaemex.mx)

Groundwater is the main source of drinking water in Toluca Valley, Mexico. The agricultural and industrial sectors have recently been overexploiting this resource, causing problems such as modification of the regional patterns of groundwater flow, progressive disappearance of water sources in mountainous areas, fractures at the ground surface, soil subsidence, and degradation of water quality. The project's objectives are to analyse groundwater resources and estimate and model soil subsidence caused by abusive pumping of groundwater. This year, **Richard Martel** and his collaborators (**Alfonso Rivera** of GSC, René Therrien of *Université Laval*, and Jaime Garfias Soliz of CIRA) worked on a numerical model for flow and subsidence.

El agua subterránea es la fuente principal de agua potable en el Valle Toluca, México. La reciente sobreexplotación no sustentable del acuífero por el sector agrícola e industrial a provocado modificaciones de los patrones regionales del escurrimiento subterráneo, la desaparición progresiva de fuentes de agua en las montañas, la aparición de fracturas en la superficie del suelo, el hundimiento del suelo (subsidencia) y una degradación de la calidad del agua. El objetivo del proyecto es realizar un balance de los recursos hídricos, evaluar y establecer un modelo de la subsidencia de los suelos provocados por el bombeo abusivo del agua subterránea. Este año, el equipo de trabajo del profesor Richard Martel y sus colaboradores (Alfonso Rivera de la Comisión Geológica de Canadá, René Therrien de la Universidad Laval y Jaime Garfias Soliz del CIRA) trabajaron en la modelización numérica de la escorrentía y de la subsidencia.

Translation: Maikel Rosabal Rodriguez

Claudio Paniconi's research activities focus on hydrological modeling at the scale of the slope and the sub-basin. He is currently studying the interactions between surface and groundwater with the goal of improving the quality of model predictions and resolving the compromise between a model's complexity and effectiveness.

He is collaborating with French and Tunisian researchers on the development of an integrated management plan for water resources for the Cap Bon basin in Tunisia. The project includes hydrological, hydrogeological, and water quality analyses. Management aspects, such as the various water uses, will also be considered.

Claudio Paniconi also continues to study water resources in the Châteauguay River watershed in collaboration with his colleagues **Alain N. Rousseau**, **René Lefebvre**, and **Jean-Pierre Villeneuve**. **Miroslav B. Nastev** (GSC) is also involved in this Ouranos Consortium project. One of the goals of the project is to improve hydrological models in order to make them sensitive to interactions between surface and groundwater.

Claudio Paniconi, **René Lefebvre**, and **Richard Martel** have completed their analysis of an underwater collection system using horizontal wells for Quebec City.

Alain N. Rousseau is contributing to a project of the Ouranos Consortium, led by **Christine Rivard** (GSC), to analyse current and future trends in aquifer recharges in Canada. Ouranos climatic projections are being used to understand the possible causes of modifications in recharge rates and to evaluate climate change impacts on those rates.

• Environmental geology

Bernard F. Long conducted geophysical surveys to determine the position and composition of the different geological units underlying two harbour expansion projects (one in Quebec and the other in Benin).

He also led the FUDOTERAM project of the GEOIDE Network. The project's goal was to develop tools to integrate terrestrial, marine, and airborne data used in coastal erosion assessment. Data collected in this project were added to the bathymetric data bank of the Canadian Hydrographic Service. Airborne data obtained by topographic and bathymetric LIDAR were also combined for Transports Quebec.

For more information

Collin, A., Archambault, P. & Long, B. (2008). Mapping the shallow water seabed habitat with the SHOALS. *IEEE Trans. Geosci. Remote Sens.* 46(10): 2947–2955. http://dx.doi.org/10.1109/TGRS.2008.920020

Richard Martel began a project on radon in homes in collaboration with Quebec's National Institute of Public Health and his colleagues **Lyal Harris** and **Marc Richer-LaFlèche.** The purpose of the project is to help the government determine the zones at greatest risks of elevated radon levels in homes. They are analyzing available data and field surveys to establish if there is

a relationship between underlying rock structure and radon levels.

• Paleoenvironmental studies

Yves Bégin specializes in dendrochronology. He is working on a reconstruction of the hydrographic and hydrological changes that have occurred in subarctic Quebec during the Holocene.

Working in collaboration with Environment Canada, his team used dendrochronological methods to reconstruct variations in key climatic variables for bird habitats in boreal forests. The final goal of the project is to identify the bird species that are most sensitive to climatic extremes in order to guide future conservation actions in the context of climate change.

Yves Bégin leads the Analysis of Past Hydro-Climatic Variations in Nunavik project, which is part of phase II of the ArcticNet Network research program. The new ARCHIVES (*Analyse Rétrospective des Conditions Hydroclimatiques à l'aide des Indicateurs de leur Variabilité à l'Échelle Séculaire*, archives.ete.inrs.ca) project is part of ArcticNet. ARCHIVES' objective is to document the hydrological and climatic variability in boreal and subarctic Quebec over the last 1000 years using natural indicators such as tree rings and lake sediments (contribution of **Pierre Francus**). This 5-year project is being conducted in partnership with the Ouranos Consortium and Hydro-Québec and within the *Centre d'études nordiques*, an interinstitutional strategic research group. Numerous collaborators from Quebec (**Christian Bégin** and **Martine M. Savard**, GSC) and from abroad are involved.

Pierre Francus' research program focuses on the study of annually laminated lake sediments (varves), in particular those of the Canadian High Arctic. Analysis of long-varved sedimentary sequences makes it possible to quantitatively reconstruct past environments.

For more information

Francus, P., Bradley, R., Lewis, T., Abbott, M., Retelle, M. & Stoner, J.S. (2008). Limnological and sedimentary processes at Sawtooth Lake, Canadian High Arctic, and their influence on varve formation. *J. Paleolimnol.* 40(3): 963-985.

http://dx.doi.org/10.1007/s10933-008-9210-x

He is also participating in two important projects at the Canadian and international levels. Cape Bounty Arctic Watershed Observatory (geog.queensu.ca/cbawo) is a Canadian IPY project that seeks to understand how climate change affects rivers, soils, and vegetation in the High Arctic, while 2000 Years of Climate Variability from Arctic Lakes (www.arcus.org/synthesis2k) is an international project of the Arctic2k work group (www.pages.unibe.ch/science/2k/arctic2k) of PAGES (Past Global Changes). The goal of the latter project is to synthesize data on the chronology and variability of changes in the Arctic climate over the last 2000 years.

An international collaboration

German partner – Deutsche Partnerschaft:
Institut für Geographie, Universität Bremen
(www.geopolar.uni-bremen.de)

Bernd Zolitschka of the University of Bremen (Germany) coordinates PASADO (Potrok Aike Maar Lake Sediment Archives Drilling Project, www.pasado.uni-bremen.de), an international research initiative within the ICDP (International Continental Scientific Drilling Program, www.icdp-online.org). **Pierre Francus** leads the Canadian contribution to PASADO (can-pasado.ete.inrs.ca). The project's goal is to study a series of long sediment cores in order to reconstruct past climate at high latitudes of the Southern Hemisphere. The PASADO field drilling campaign took place in the fall of 2008 in Laguna Potrok Aike in southern Patagonia, Argentina. Core analyses are underway. The INRS team (**Pierre Francus, Isabelle Larocque**, and **Pierre-Simon Ross**) focuses on the sedimentology, paleoecology, and volcanology of the deposits. **Pierre-Simon Ross** studies the Quaternary maars of a volcanic field in order to better understand the impact of an unconsolidated substrate on volcanic eruptions. **Pierre Francus** is also responsible for ICDP-Canada (www.icdp-canada.ca), whose activities have just started.

Bernd Zolitschka von der Universität Bremen in Deutschland ist Leiter des PASADO-Projektes (*Potrok Aike Maar Lake Sediment Archives Drilling Project*), welches eine Initative der internationale Forschung im Rahmen des ICDP (*International Continental Scientific Drilling Program*) darstellt. Pierre Francus ist für die Leitung der kanadischen Beteiligung an PASADO verantwortlich. Ziel des Projektes ist es, eine Serie langer Sedimentbohrkerne zu studieren und auf diese Weise das Paläoklima der hohen Breitengrade der Südhemisphäre zu rekonstruieren. Die Feldarbeit des PASADO-Projektes wurde im Herbst 2008 in der Laguna Potrok Aike in Südpatagonien, Argentinien, durchgeführt, und die Analyse der gewonnenen Sedimentbohrkerne ist zur Zeit in vollem Gange. Die Wissenschaftler der Forschungsgruppe des INRS, die aus Pierre Francus, Isabelle Larocque und Pierre-Simon Ross besteht, beschäftigen sich in erster Linie mit der Sedimentologie, der Paläoökologie und den vulkanischen Ablagerungen der Bohrkerne. Pierre-Simon Ross erforscht die quartären Maare eines Vulkanfeldes, um den Einfluss von ungefestigtem Substrat auf Vulkanausbrüche besser zu verstehen. Pierre Francus ist ebenfalls Verantwortlicher des kürzlich angelaufenen Programmes ICDP-Canada.

Translation: Claudia Zimmermann

PASADO drilling, Laguna Potrok Aike, Patagonia

• Geophysical applications in archaeology

Marc Richer-LaFlèche continued his geophysical work with several archaeological projects in Quebec City. Using trace-elements geochemistry and lead isotopes, he was able to determine the provenance of numerous artefacts and materials of the *Îlot des Palais* collections. He also completed a geophysical study to locate archaeological artefacts of the Cartier–Roberval period in Cap-Rouge in collaboration with Quebec City archaeologists.

Scientific collaboration

20th anniversary of the *Centre géoscientifique de Québec*

www.cgq-qgc.ca

The *Centre géoscientifique de Québec* (CGQ) was officially inaugurated on 1 October 1988; it thus celebrated its 20th anniversary this year. The *Centre Eau Terre Environnement* and the Quebec division of the Geological Survey of Canada (GSC-Quebec) are partners within the CGQ under a scientific collaboration agreement between the INRS and Natural Resources Canada. This university–government partnership facilitates collaboration among researchers in the fields of natural resources and the environment. Researchers of the CGQ focus their activities on important socio-economic issues, increasing knowledge related to georesources (groundwater, minerals, and fossil fuels) and environmental geosciences (natural hazards, environmental geodynamics, characterization and restoration of contaminated sites, and climate change). The CGQ optimizes the use of resources by sharing research rooms and laboratories, a library, various expenses, and promoting scientific collaborations, while respecting each partner's autonomy. Yves Bégin, director of the *Centre Eau Terre Environnement*, and Donna Kirkwood, director of the GSC-Quebec, supervise the functioning of the CGQ.

The common objective is to maintain a centre of convergence and excellence in geosciences, open to all, while promoting collaboration among the governments, agencies, and universities of Eastern Canada. Inter-university programs of graduate studies in earth sciences are offered by the *Centre Eau Terre Environnement*, in conjunction with the *Université Laval*. GSC-Quebec researchers are associate professors and as such are able to supervise Master's and PhD students. Another goal of the CGQ is to promote public interest in geosciences and help to train future

geoscientists. To achieve this, the CGQ produces outreach materials and participates in public events, in particular those that are designed to raise students' interest in science.

Centre Eau Terre Environnement research chairs

• MDDEP Research Chair on Geological Sequestration of CO_2

chaireco2.ete.inrs.ca

Chairholder: **Michel Malo**

This new chair is financed by Quebec's Ministry of Sustainable Development, Environment and Parks (MDDEP). The chair's objectives are to evaluate the CO_2 storage capacity in Quebec, test a few sites for their CO_2 storage potential after injection, and create expertise in Quebec in the field of CCS (Carbon Capture and Sequestration). Several of the Centre's researchers participate in the chair's work, including **Bernard Giroux**, **Erwan Gloaguen**, **René Lefebvre**, and **Normand Tassé**, as well as **Mathieu J. Duchesne** (GSC).

• Canada Research Chair in Environmental Decontamination

Chairholder: **Jean-François Blais**

This research chair is engaged in developing innovative procedures for decontaminating certain types of environments and industrial and urban waste, specifically sludge generated by wastewater treatment, fly ash produced by waste incineration, mine tailings, and soils polluted by toxic metals.

• Canada Research Chair in Metal Ecotoxicology

Chairholder: **Peter G.C. Campbell**

This chair's financing has been renewed this year. The chair's objectives are to develop new approaches to assess the environmental impacts of metals taking into account their specific properties. The research team is developing models for metal bioaccumulation in aquatic organisms and innovative methods to detect metal effects on those organisms and study their capacity to detoxify the accumulated metals. **Patrice Couture**, **Claude Fortin**, and **Landis Hare** take part in the chair's work.

• Canada Research Chair in Hydrological Variable Assessment

Chairholder: **Taha B.M.J. Ouarda**

This chair's financing was renewed last year. The chair's focus is on the study of watercourse flow variations based on hydrological data and statistical models. The research program comprises three main aspects: frequency analysis of hydrometeorological variables at the a) local and b) regional levels, and c) modeling of the uncertainties associated with assessing those variables. The theoretical results obtained have practical applications within the work of the research group's industrial chair.

• Research Chair in Statistical Hydrology (NSERC – Hydro-Québec)

Chairholders: **Taha B.M.J. Ouarda** (75%)
and **Anne-Catherine Favre** (25%)

The third phase (2004–2009) of this chair's scientific program comprises four main research axes. Two of these, "Developing tools to assist in the design of hydroelectric structures" and "Analysis and modeling of time series", are in line with the work of the previous phases, whereas the two new ones, "Environmental statistical hydrology" and "Statistical hydrology in northern environments", explore new research topics. **André Saint-Hilaire** and emeritus professor **Bernard Bobée** participate in the chair's work.

• Canada Research Chair on Bioconversion of Wastewater and Sewage Sludge into High-Value-Added Products

Chairholder: **Rajeshwar Dayal Tyagi**

This chair's work is aimed at developing new cost-effective, ecological processes for treating and converting wastewater and sewage sludge into high-value-added products. These biological materials include bio-insecticides, bio-herbicides, biofungicides, bio-inoculants, and bioplastics. The use of such products will help to reduce or minimize our dependence on chemical substances in agriculture, forestry, and industry.

Participation in other inter-institutional research groups

- CARTEL (*Centre d'applications et de recherches en télédétection*)

www.usherbrooke.ca/cartel

Associate researchers: **Monique Bernier**, **Alain N. Rousseau** and honorary professor **Jean-Pierre Fortin**

- CEN (*Centre d'études nordiques*)

www.cen.ulaval.ca

Co-director: **Monique Bernier**
Regular members: **Yves Bégin**, **Isabelle Laurion** and **Taha B.M.J. Ouarda**
Associate member: **Pierre Francus**

- CIRÉ (*Centre interinstitutionnel de recherche en écotoxicologie du Québec*)

www.ecotox.uquebec.ca

Members: **Jean-François Blais**, **Peter G.C. Campbell**, **Patrice Couture**, **Claude Fortin**, **Charles Gobeil**, **Guy Mercier**, **Rajeshwar Dayal Tyagi** and honorary professor **Michel Leclerc**

- CIRSA (*Centre de recherche interuniversitaire sur le saumon de l'Atlantique*)

www.bio.ulaval.ca/cirsa

Full members: **Normand E. Bergeron** and **André Saint-Hilaire**
Honorary member: **Michel Leclerc**

- GEC3 (Global Environmental and Climate Change Centre)

www.geog.mcgill.ca/gec3

Full members: **Taha B.M.J. Ouarda** and **André Saint-Hilaire**
Affiliated member: **Michel Slivitzky** (emeritus professor)

- GEOTOP (*Centre de recherche en géochimie et en géodynamique*)

www.geotop.ca

Members: **Pierre Francus** and **Bernard F. Long**

- GRIL (*Groupe de recherche interuniversitaire en limnologie et en environnement aquatique*)

www.gril-limnologie.ca

Full members: **Normand E. Bergeron**, **Landis Hare** and **Isabelle Laurion**
Honorary member: **André Tessier**

- Québec-Océan (*Groupe inter-institutionnel de recherches océanographiques du Québec*)

www.quebec-ocean.ulaval.ca

Full members: **Charles Gobeil** and **Yves Gratton**

- TOXEN (Centre de recherche en toxicologie de l'environnement)

Regular members: **Peter G.C. Campbell** and **Claude Fortin**

Sharing knowledge

Publications

- Journal of Water Science

www.rse.inrs.ca/english/index.php?page=accueil

Co-director: **Peter G.C. Campbell**
Editorial board members: **Jean-François Blais** and **Alain Rousseau**
Scientific board member: **Bernard Bobée** (emeritus professor)

This is an international electronic journal publishing original research papers in pure and applied water science, notably in the areas of hydrology (surface and groundwater), water quality, hydrobiology, ecotoxicology, potable water and wastewater treatment, and water resources management. It is co-edited by

the *Groupement d'Intérêt Scientifique des Sciences de l'Eau* (France) and the *Centre Eau Terre Environnement* (INRS).

• Scientific publications and communications

Most of the research reports and graduate theses of the *Centre Eau Terre Environnement* are available online:

www.ete.inrs.ca/index.php?page=5

The complete listing of the 2008–2009 scientific publications and communications of *Centre Eau Terre Environnement* researchers is available online:

www.ete.inrs.ca/doc/publications2008-2009.pdf

Meetings and seminars

• Seminar program

www.ete.inrs.ca/index.php?page=1_6

The *Centre Eau Terre Environnement* holds scientific seminars related to its various research fields throughout the year.

• Meetings and workshops

Several events were organized at the Centre this year. For example, the 2nd FUDOTERAM workshop on bathymetric LIDAR applications was held on 26 and 27 March 2009. **Bernard F. Long**, who led the FUDOTERAM project within the GEOIDE Network, co-organized this workshop with a researcher from the University of New Hampshire. On April 20th the first meeting of the Research Chair on Geological Sequestration of CO_2 was held. Professor **Michel Malo** is the chairholder. The meeting's theme was "The Capture and Sequestration of Carbon in Quebec: Who Are the Actors?"

• Earth and Environmental Sciences Day

www.ggl.ulaval.ca/jst2009

Several *Centre Eau Terre Environnement* students participated in the 10th annual Earth and Environmental Sciences Day held at the *Université Laval* on 27 March 2009. This joint event is organized alternately by students of the INRS and *Université Laval*. This conference day is an excellent opportunity for graduate students to present their research results to an informed audience. Some members of the Centre received distinctions for the quality of their oral (**Asma Chemingui**, PhD student supervised by Claudio Paniconi) and poster (**Julie Anaïs Debreil** and **Guillaume Jouve**, PhD students supervised by Pierre-Simon Ross and Pierre Francus, respectively) presentations.

Public outreach activities

Centre Eau Terre Environnement researchers regularly give interviews and contribute to articles in the media (newspapers, radio, television, Internet) within their specialty field.

In summer 2008, *Découvrir* magazine of the *Association francophone pour le savoir* (ACFAS) published articles on the work of two of the Centre's researchers. The first article explained the formation of thermokarst ponds and their role in greenhouse gas emissions, a subject of great interest to **Isabelle Laurion**. The second article described statistical modeling, a speciality of **Taha B.M.J. Ouarda**, as an essential tool in the good management of water resources. In addition, **Yves Gratton** gave several interviews about his work on ocean circulation as part of various media reports on research activities on the icebreaker Amundsen.

In October, two researchers of the Centre were interviewed for the public outreach scientific radio show *Les Années Lumière* at Radio-Canada. **Pierre Francus** talked about the Pingualuit Crater Lake in Nunavik, the deepest lake in Quebec. **Michel Malo** described the technology of carbon sequestration for a report on that subject. He also gave many other interviews after his new chair was announced.

In December, the newspaper *Le Soleil* published a series of articles on 10 important scientific findings of 2008. One of the articles mentioned the contribution of **Pierre Francus** to a European study that reconstructed the climate of the Sahara during recent millennia by analysing lake sediment cores.

Last year, the Documentation and Information Service of the INRS launched a series of information bulletins called *Capsules INRSciences*, which are designed to highlight in easily understood language and format the quality and diversity of research carried out by *Centre Eau Terre Environnement* students. The four

bulletins published this year are available online: www.ete.inrs.ca/index.php?page=5_2

Many students and professors of the Centre shared their passion for research during a public event held in Place Laurier (a shopping centre in Quebec City) on 18 April as part of Earth Day 2009 activities.

Research excellence

Several *Centre Eau Terre Environnement* researchers and students received awards this year for the excellence of their research or the quality of their scientific presentations.

Professors **Sophie Duchesne**, **Alain N. Rousseau**, and **Jean-Pierre Villeneuve** received the Arnold Drapeau Award from the *RÉSEAU environnement* network for the excellence of their article on the evolution of and possible solutions to world water problems that appeared in early 2008 in the *VECTEUR environnement* online journal.

Associate researcher **Elena Konstantinovskaya** and Professor **Lyal Harris** received the 2008 David Elliot Best Paper Award of the Geological Association of Canada for an article entitled "Transfer zones and fault reactivation in inverted rift basins: Insights from physical modelling" published in *Tectonophysics* in 2007. They also received a prize for the best abstract in geology for a poster presented to the CSPG CSEG CWLS Joint Convention held in May.

At the 5th Society of Environmental Toxicology and Chemistry (SETAC) World Congress in Australia in August, **Isabelle Proulx** (a PhD student supervised by Landis Hare) was awarded a prize for the best student oral presentation. She also received an award of excellence from the *Chapitre Saint-Laurent*, an organization in Quebec affiliated with SETAC, for her PhD project, which aims to explain the differences in metal accumulation patterns between sympatric species of Chironomidae larvae.

In fall 2008, Professor **Michel Malo** was appointed to the *Cercle d'excellence* of the *Université du Québec* in recognition of his leadership in geological research.

Three students of the Centre received awards at the 6th annual *Lab-oratoire public* (a university research outreach contest) held in October. **Josée-Anne Majeau** and **Jean-Philippe Chenel** (PhD students supervised by Professor R.D. Tyagi) obtained the first prize of the Jury in the Sciences and Engineering category, and **Samuel Bolduc** (a Master's student with Alain Mailhot) obtained the third prize.

Christiane Dupont, a Master's student supervised by Isabelle Laurion, won the 2008 ACFAS Research Outreach Award for her article on thermokarst ponds.

In November, **Geneviève Bordeleau** received the excellence scholarship from the Director General at the INRS convocation ceremony. She successfully completed a Master's degree on the environmental impacts of military training activities under the supervision of Richard Martel. She is now pursuing PhD studies with the same research group.

In January 2009, at the annual symposium of the MITHE (Metals in the Human Environment) Strategic Network, two of the three prices awarded for the best student posters were given to members of the Centre: **Dominic Ponton**, a Master's student with Landis Hare, and **Kristin Mueller**, a PhD student co-supervised by Peter G.C. Campbell and Claude Fortin.

In April, at the 12th CIRSA (*Centre Interuniversitaire de Recherche sur le Saumon Atlantique*) Annual Meeting, the *Fondation de la faune du Québec* presented three prizes for the best student presentations. Two PhD students from the Centre were among the winners, **Patricia Johnston** (from Normand E. Bergeron's research team) and **Valérie Ouellet** (supervised by André Saint-Hilaire).

Professor **Alain N. Rousseau** received a distinction in the Governance category at the General Assembly of the Montmorency River Watershed Committee held in May. Dr. Rousseau's flood prediction model enables a better emergency response when sections of the river are threatened by flood.

In May, two students from the Centre received awards during two different annual meetings. **Raoul-Marie Couture** (a PhD student supervised by Charles Gobeil) received an award of excellence at the Annual Meeting of the *Chapitre Saint-Laurent* for his PhD project in aquatic biogeochemistry. At the 11th Annual Scientific Conference of the GEOIDE Network, **Valérie Robitaille** (a Master's student with Bernard F. Long) obtained the Excellence Prize in Communication in recognition of the quality of her presentation.

A glance at the Centre's links throughout the world

In 2008-2009: Research sites (dots); Countries of origin of Centre's members (in green); Countries of origin of researcher collaborators (in light blue); Combination of the two preceeding categories (in dark blue).

Training of highly qualified personnel

The students of the *Centre Eau Terre Environnement* of the INRS are in direct contact with real and concrete problems in water and earth sciences. Six graduate programs are offered. The inter-university Master's and PhD programs in earth sciences are operated in collaboration with the Geology and Geological Engineering Department of the *Université Laval*. The students are registered in either institution but are trained by both. This collaboration has several advantages for the students: a wider choice of research subjects, a more extensive list of courses, and access to the services offered by both institutions. Students also benefit from the partnership between the INRS and the Geological Survey of Canada, which substantially increases the number of potential research advisors. In addition, a co-supervised PhD student registered at the INRS and a French university can obtain a diploma in each of the two institutions. The France–Quebec cooperation program makes this possible.

The Centre's graduate programs:

www.ete.inrs.ca/index.php?page=4_1

Water sciences programs

• PhD in water sciences

Several scientific disciplines are required to understand problems in water resources and aquatic environments, and a complete multidisciplinary approach is necessary to find solutions. This program is designed to train specialized researchers capable of defining and solving these problems, thus meeting society's needs in this domain. Students in this program will widen and deepen their general knowledge in water sciences while specializing in one of the specific fields of studies.

• Master's in water sciences

The INRS is the only institution in Quebec to offer a Master's in water sciences. This program enables students to acquire the specialized knowledge necessary to study the problems associated with this fundamental resource. In the thesis program, students can demonstrate their originality and aptitude for research while specializing in one or two fields of interest, selecting from a choice of three courses.

• Professional Master's in water sciences

The Master's program without thesis is designed to train professionals in executing and managing water science projects. Through the general knowledge and specialization obtained, graduates are able to make a significant contribution to solution finding and decision making in this area. This program also seeks to meet the continuing education needs of water science professionals.

Hydrology student personality

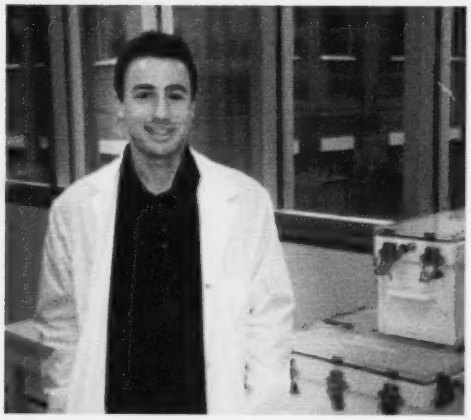
After her Bachelor degree in geography, **Elsa Goerig** worked for two years as a project officer in a watershed management organization. During her undergraduate studies, she did an internship at the INRS in the research group of Professor Normand E. Bergeron. In 2008, she obtained an NSERC graduate scholarship to start a Master's degree with the same research group. Her Master's subject suits her perfectly since she loves both being in the water and being in the forest. She studies the passage of fish of the salmon family in road culverts. Her main partner on the project is Transports Quebec. The goal is to develop a predictive model for the passage success of brook trouts in culverts, a model that includes biological, hydrological, and environmental variables. PIT-tag (Passive Integrated Transponder) technology is used to follow the fish. She is currently working in the field, studying tributaries of the Sainte-Marguerite River in the Saguenay region. In contrast to her parents, who immigrated from France, Elsa and her family (her husband and two young boys) live where she grew up, near Maskinongé in Mauricie.

Decontamination student personality

Bala Subramanian Sellamuthu completed his Bachelor and Master's degrees in microbiology and molecular biology in his native India. As a student, he worked at the Bhabha Atomic Research Centre. Later, he joined the Naval Materials Research Laboratory as a research fellow (for four years) and as a scientist (for a year and a half). He then secured a FQRNT fellowship to pursue doctoral studies in Quebec at the INRS. This year, he successfully completed his PhD under the supervision of Professor R.D. Tyagi. The aim of his doctoral research was to achieve bioflocculation of sludge. This has important applications since sludge disposal is an ever-increasing environmental and economic problem. So far, synthetic polymers (SPs) have been used to facilitate sludge flocculation and settling prior to dewatering, but SPs are expensive, toxic, and non-biodegradable. Thus, their use should be eliminated or at least minimized. To achieve this, eco-friendly bioflocculants produced by microorganisms can be used. Bala studied two different bioflocculation processes, biopolymers and floc-forming strains. His PhD results will lead in the near future to a new process for cost-effective production of bioflocculants for sludge dewatering. Over the years, Bala has received several distinctions and has been a very prolific author, producing one patent and publishing 11 articles in peer-reviewed journals, 14 papers in conference proceedings, 17 book chapters, and 9 scientific reports. He also has submitted 69 gene sequences to GenBank.

Biogeochemistry student personality

Raoul-Marie Couture began a Master's degree at the INRS in 2004 under the supervision of Professor Charles Gobeil. A year later, he switched to a PhD degree to dig further into his research subject, the geochemical cycle of arsenic in aquatic environments. Arsenic (As) is a toxic metal identified as a priority contaminant in Quebec and around the world. Raoul is currently completing his thesis, which seeks to describe the chemical reactions that control the mobility of As within sediments, reconstruct the history of atmospheric contamination by As using sedimentary archives, and predict the response of As accumulation to environmental changes. Raoul is passionate about chemistry research and... travelling. He succeeded in combining his two passions during his PhD by doing three internships in European laboratories, which enabled him to widen his knowledge and establish productive collaborations. He is currently an invited researcher at CEREGE (a European research and training centre on environmental geosciences) in Aix-en-Provence, France. Next spring, he will undertake another great intellectual voyage, this time in our southern neighbouring country, as a postdoctoral fellow at the Georgia Institute of Technology in Atlanta.



Earth sciences programs

• PhD in earth sciences

This program offers advanced specialization in various fields of fundamental and applied geology and geological engineering. The program is designed to train students to conceive and set up original research projects, to lead projects on their own, and to excel in professional research or university teaching activities.

• Master's in earth sciences

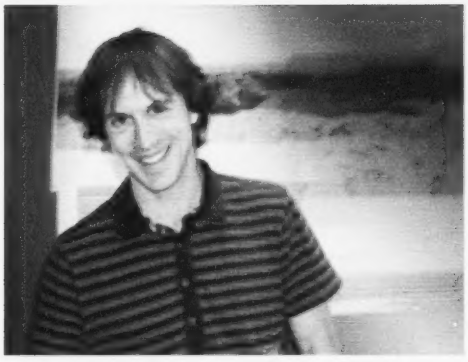
In the Master's thesis program, students acquire advanced general knowledge, deepen their knowledge in a specific field, are introduced to scientific research, and are trained in the professional practice of geology, hydrogeology, or geological engineering.

• Master's in earth sciences – Environmental technologies

This program with essay leads to a Professional Master's degree specializing in environmental technologies. In most jobs, employees are confronted with environmental problems. Practical approaches for problem solving are interdisciplinary and require diversified knowledge from a whole set of disciplines. The Professional Master's is focused on environmental technologies used in civil, chemical, geological, and agroalimentary engineering and in the environmental sciences of soil, water, and air decontamination, waste recycling, and pollution reduction.

Geosciences student personality

Daniel Paradis chose the subject of his PhD very thoughtfully. Indeed, all his academic and professional activities have been directed towards his main motivation: finding practical solutions to problems that affect peoples' lives. After a Bachelor degree in physical engineering, he completed in 2000 a Master's at the INRS with the research group of Professor Richard Martel. He then worked in geological sciences for a number of organizations, including the Geological Survey of Canada (GSC), where he has worked as a research fellow since 2001. The experience he gained with the GSC enabled him to determine precisely the PhD project he wanted to do. He is currently pursuing his thesis at the INRS under the supervision of Professor René Lefebvre. The main objective of his project is to develop means of characterizing and integrating hydrogeological information in order to improve our understanding of aquifer dynamics. 2007 was a fruitful year for Daniel. A GSC study on nitrates in groundwater in which he took part won an achievement award from Natural Resources Canada for its exceptional contribution to the work of the department, while his PhD project brought him to Colorado to work with researchers of the United States Geological Survey. In addition to combining work for the GSC and his PhD project, Daniel makes sure not to neglect his two other passions: his family (he has two children) and running!



Internships and fellowships

As part of its mission to conduct research and train highly qualified personnel, the INRS welcomes postdoctoral fellows in its research groups. Postdoctoral scholarships are available.

INRS postdoctoral fellowships:
www.inrs.ca/Francais/index.jsp?page=StagesPostDoc

Each summer, the *Centre Eau Terre Environnement* offers undergraduate internships, an excellent opportunity for students to gain research experience in the fields of water, environmental sciences, and natural resources in a highly stimuling scientific environment.

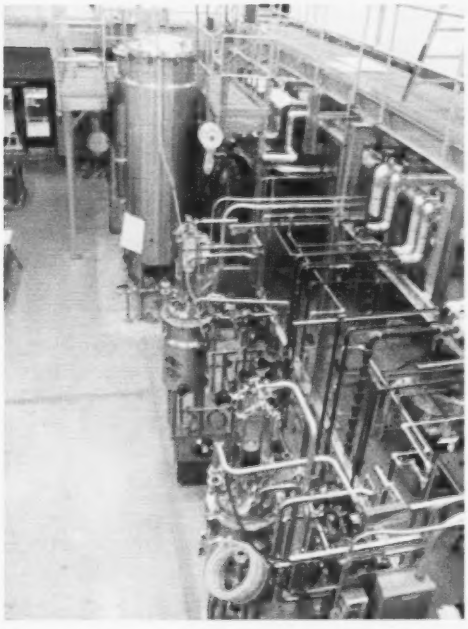
The Centre's summer internships:
www.ete.inrs.ca/index.php?page=1_5

High-quality research infrastructure

The *Centre Eau Terre Environnement* of the INRS is located in downtown Quebec City on the urban campus of the *Université du Québec*. Its research groups have access to state-of-the-art laboratories and equipment (ultra-clean laboratory, ITRAX scanner, scanning electron microscope, plasma-atomic emission spectrophotometer, etc.).

The large-scale laboratories are housed in a new building located in the Metropolitan Quebec Technology Park. This building contains high-tech equipment unique in Canada, including CAT scan and environmental biotechnologies laboratories. These facilities will enable the scaling of technologies developed at the Centre.

Large-scale laboratory building at the Technology Park



Fermenters for decontamination work

In addition, a research station located at Sacré-Cœur (Saguenay region) offers INRS research groups a work and educational facility for seminars, training courses, study projects, and scientific meetings in a natural environment. The station is also available for inter-university collaborations.

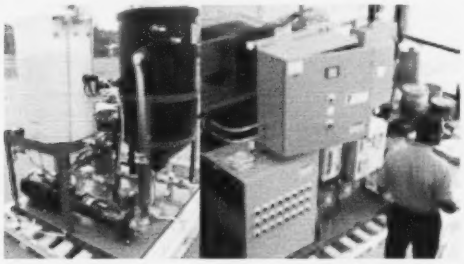
Shared services laboratory

www.ete.inrs.ca/lab.php?page=lab1

The shared services laboratory located in the downtown building comprises a general laboratory and several specialized laboratories in microbiology, radio-isotopes, chemical analyses, sample preparation, microscopy, trace metals, etc. The operating mode of this laboratory is unique in that all equipment and instruments bought by professors with their grants are pooled and are available to everybody. This enables optimal use of all resources. A complete range of high-tech instruments is thus at the disposal of everyone involved in experimental research at the Centre.

Research laboratories

The Canadian Foundation for Innovation has financed in part the set up of two new laboratories at the Centre this year. **Patrick Drogui** is responsible for the new Laboratory of Environmental Electrotechnologies and Oxydative Processes (LEEPO). The infrastructure housed in the large-scale laboratories at the Technological Park includes specialized equipment for conceiving, testing, and optimizing electrolytic units. The electrolytic techniques and oxydative processes to be developed will be used to improve existing wastewater treatment systems or replace current technologies ineffective for the removal of refractory organic, inorganic, and microbial contaminants.



LEEPO pre-industrial pilot unit

Erwan Gloaguen is responsible for the new Laboratory of Geophysical Data Acquisition and Interpretation. The equipment obtained for this laboratory includes a ground penetrating radar system, a resistivity meter for imaging, a seismograph, and a Time-Domain Electromagnetic Methods (TDEM) system. This new laboratory will facilitate the study of contamination types and dynamics and the characterization of contaminated sites from the perspective of rehabilitation.

Christine Bélanger, geophysical field measurements, Saint-Lambert-de-Lauzon

The research group of **Satinder Kaur Brar** has acquired equipment that will eventually be integrated into a new laboratory on bioprocesses and bionanotechnologies. Its refrigerated incubator shaker for the growth of microorganisms will be used to develop formulations of added-value products, conduct biodegradation studies of toxic organic compounds, and prepare bacteria, yeast, and fungal inocula for bench-scale fermenters. A solid-state fermenter and a high-speed grinder (for preprocessing) have also been obtained and will be used in the fermentation of agribusiness solid waste.

Finally, the partnership between the *Centre Eau Terre Environnement* of the INRS and the Quebec division of the Geological Survey of Canada (GSC-Quebec) enables the pooling of high-quality geoscience laboratories accessible to the entire research community.

For more information on the *Centre Eau Terre Environnement* research laboratories:
www.ete.inrs.ca/index.php?page=laboratoires

- High-Resolution Paleoclimatic Analysis (LAPAHR)
- Environmental Technologies (Decontamination)
- Bioconversion of Wastewater and Sewage Sludge into High-Value-Added Products
- Bio-Optics and Microbial Ecology
- Ultra-Trace Geochemistry
- Geochemistry, Imagery, and Radiography of Sediments (GIRAS)
- *In situ* Decontamination of Soil and Groundwater (Joint lab INRS – DRDC-Valcartier)
- Trace Metal Measurements in Aquatic Samples
- Multidisciplinary CAT Scan
- Physical, Digital, and Geophysical Simulation
- Direct Push and Rotary Percussion Sounding System
- Remote Sensing and Geomatics

For more information on GSC-Quebec research laboratories: **cgc.rncan.gc.ca/org/quebec/lab_e.php**

- Analytical Geochemistry (Joint lab INRS – GSC-Quebec)
- Stable Isotope Geochemistry (Delta-Lab)
- Hydrogeology
- Dendrochronology and Dendrogeochemistry
- Digital Cartography and Photogrammetry Laboratory (LCNP)

Centre Eau Terre Environnement
community

Research and teaching

Research teams

- professor
- research technician
- research associate
- research officer
- research assistant
- postdoctoral fellow
- PhD student
- Master's student
- intern
- others

❍ of one of the above colors:
left or graduated during the year

■ Jean-Christian Auclair Biogeochemistry

■ Yves Bégin Dendroecology
- Joëlle Marion
- Antoine Nicault
- Mathilde Renaud
- Jean-Christophe Aznar
- Stéphanie Wicha
- Philippe Boulanger
- Thibault Labarre
- Philippe Lafrenière

■ Mario Bergeron Geochemistry
- Marie Létourneau
- Alain Langlais
- Gérald Dermont
- Jorge Enrique Medina López
- François Larouche

■ Normand E. Bergeron Fluvial geomorphology
- Francis Bérubé
- Marc-André Pouliot
- Patricia Johnston
- Benoît Turcotte
- Jean-Nicolas Bujold
- Joanie Côté
- Jérôme Dubé
- Francis Gauthier
- Elsa Goerig
- Maxime Grenier
- Véronique Tremblay
- Pierrick Bilodeau
- Jena Hare
- Audrey Moffett
- Jean-Baptiste Torterotot
- André Boivin (field assistant)

■ Monique Bernier Remote sensing
- Yves Gauthier
- Parvin Kalantari
- Jimmy Poulin
- Md. Shah Alamgir
- Maria Dissanska
- Rebecca Filion
- Imen Gherboudj
- Kim Huong Hoang
- Stéphane Mermoz
- Stéphanie Bleau
- Karine Labrecque
- Audrey Lessard-Fontaine
- Gérémy Combret
- Yann Dribault
- Charles Gignac
- Emmanuel Kabura
- Inga May
- Maxime Rousseau
- Julien Saint-Laurent

■ Jean-François Blais Decontamination
- Myriam Chartier
- Samuel De la Rochebrochard
- Amélie Janin
- Dikenane Kombila
- Stéphanie Lafond
- Lan Huong Tran
- Pascal Castellazzi
- Marie-Christine Simard
- Véronique Turcotte
- Karima Cheggari
- Soumia El Basri
- Otmane Gaboune
- Heipua Kervella
- Nazaire Mbouiti
- Marian Moucheroud
- Guillaume Nielsen
- Louis-César Pasquier

■ Satinder Kaur Brar Biological detoxification
- Fatma Gassara

■ Bernard Bobée (emeritus) Statistical hydrology
- Ouejdene Samoud

■ Peter G.C. Campbell Geochemistry
- Séverine LeFaucheur
- Fabien Pierron
- Sophie Cooper
- Kristin Mueller
- Yvan Tremblay
- Anne Crémazy

- Karem Chokmani Remote sensing and hydrology
  - Anas El Alem
  - Nabil Chaabane
  - Julien Gambelli
  - Fabien Gautreault
  - Jennifer Noël
  - Brian O'Connor
  - Benjamin Raphaël-Amanrich

- Daniel Cluis (honorary) Agricultural pollution
  - Julie Corriveau
  - Mathieu Quenum

- Patrice Couture Ecotoxicology
  - Charles Gauthier
  - Dominique Lapointe
  - Nicolas Garceau
  - Audrey Moffett
  - Berangère Leclercq

- Paul Drevnick Contaminant biogeochemistry

- Patrick Drogui Electrochemistry
  - Mandé Léa Rosine Guitaya
  - Brahima Seyhi
  - François Zaviska
  - Rimeh Daghrir
  - Isidore Moukame

- Sophie Duchesne Hydrology and hydraulics
  - Nabila Bouzida
  - Thai Nam Pham
  - Lise Audet
  - Déborah Souriau
  - Nicolas Trottier

- Anne-Catherine Favre Statistical hydrology
  - Guillaume Evin
  - Mériem Saïd
  - Karine Dion
  - Nguyen Bao Trinh
  - Thomas-Charles Fortier-Filion
  - Jonathan Jalbert
  - Maryse Champagne
  - Arthur Goussanou

- Claude Fortin Biogeochemistry
  - Jonathan Bernier
  - Laura François
  - Michel Lavoie
  - Danaé Pitre
  - Marc-André Robin
  - Gabrielle Roy
  - Aurélie Mabilat
  - Catherine Mercier Shanks

- Pierre Francus Limnogeology
  - Jean-François Crémer
  - David Fortin
  - Frédéric Bouchard
  - Nicoleta Ciobanas
  - Stéphanie Cuven
  - Guillaume Jouve
  - Vicky Tremblay

- Bernard Giroux Applied geophysics

- Erwan Gloaguen Hydrogeophysics
  - Patrick Simard
  - Christine Bélanger
  - Lorenzo Perozzi

- Charles Gobeil Biogeochemistry
  - Antony Chappaz
  - Raoul-Marie Couture
  - Stéphane Feyte
  - Marie-Noëlle Bernatchez
  - Marie-Ève Randlett

- Yves Gratton Oceanography
  - Dominique Boisvert
  - Véronique Lago
  - Marie-Emmanuelle Rail
  - Claude Bélanger
  - Maryam Kamali Nezhad
  - Dany Dumont
  - Somayeh Nahavandian Esfahani
  - Romain Lanos
  - Caroline Sévigny
  - Charles Brouard
  - Loïc Degroote
  - Antoine Roy-Gobeil

- Landis Hare Biogeochemistry
  - Isabelle Proulx
  - Karine Bertrand
  - Julien Lacharité
  - Dominic Ponton
  - Maryse Catellier-Boulianne
  - Sophie Côté

- Lyal Harris Structural geology
  - Elena Konstantinovskaya
  - Vladimir Antonoff
  - Gregory Dufrechou
  - François Leclerc
  - Jimmy Poulin

- Pierre Lafrance Biogeochemistry
  - Cédile Doukouré

- Isabelle Larocque Paleoclimatology

- Isabelle Laurion Aquatic ecology
  - Benoit Ginoux
  - Leira Retamal
  - Paul-Georges Rossi
  - Sophie Caplanne
  - Christiane Dupont
  - Annabelle Waren

- professor
- research technician
- research associate
- research officer
- research assistant
- postdoctoral fellow
- PhD student
- Master's student
- intern
- others

○ of one of the above colors:
left or graduated during the year

- Sébastien Bourget
- Yves Bouthillier
- Virginie Roy
- Laurence Roy-Grégoire
- Gabriel Sarasin
- Shohei Watanabe

■ Michel Leclerc (honorary) Ecohydraulics
- Paul Boudreau
- Pierre-Luc Fortin

■ René Lefebvre Hydrogeology
- Jean-Marc Ballard
- Marc-André Carrier
- Belkacem Lahmira
- Lise Lamarche
- Daniel Paradis
- Laurie Tremblay
- Patrick Brunet

■ Bernard F. Long Sedimentology
- Louis-Frédéric Daigle
- Régis Xhardé
- Antoine Collin
- Antoine Cottin
- Stéphane Montreuil
- Valérie Robitaille
- Yann Keramoal

■ Alain Mailhot Urban hydrology
- Guillaume Talbot
- Ahmadi Kingumbi
- Samuel Bolduc
- Simon Lachance-Cloutier

■ Michel Malo Structural geology
- Karine Bédard
- Gaëlle Grundman
- Adeline Parent
- Jean-François Ravenelle
- Stéphanie Roy
- Kenneth Williamson
- Linda Aubert (secretary)
- Rudolf Bertrand (consultant)

■ Richard Martel Hydrogeology
- Clarisse Deschênes-Rancourt
- Richard Lévesque
- Sébastien Côté
- Étienne Girard
- Thomas Robert
- Luc Trépanier
- Uta Gabriel
- Vincent Boulianne
- Isabelle Châtillon
- Sandra Fournier
- Nicolas Francoeur-Leblond
- Sébastien Lange
- Geneviève Bordeleau
- Angus Calderhead
- Mathieu Laporte-Saumure
- Aurélie Bellavance-Godin
- Martin Blouin
- Guillaume Comeau
- Jean-Philippe Drolet
- Marie-Claude Lapointe
- Geneviève Parent
- Marie-Catherine Poulin-Talbot
- Mathieu Boucher
- Isabelle-Julie Brisson
- Maxime Grenier
- Samuel Roy
- Javier Salas Garcia
- Véronika Varfalvy
- Linda Aubert (secretary)

■ Guy Mercier Decontamination
- Aurélie Dhenain
- Romain Barbaroux
- Julia Mouton
- Élaine Boutin
- Charles-Edouard Nanci
- Louis-César Pasquier
- Vincent Taillard
- Nam Tran
- Patrick Bégin
- Nathalie Chareyron
- Yannis Ferro
- Fabien Jeuland
- Michel Plourde
- Darren Poiré

■ Taha B.M.J. Ouarda Statistical hydrology
- Fateh Chebana
- Salaheddine El Adlouni
- Naveed Khaliq
- Hua Cai
- Christian Charron
- Étienne Boucher
- Jacquie Diatezua
- Eghbal Ehsanzadeh
- Dominique Fasbender
- Tae Sam Lee
- Hadiza Moussa Saley

- Chang Shu
- Lampouguin Bayentin
- Claudie Beaulieu
- Edgar Herrera-Guzman
- Bahaa Khalil
- Mathieu Ribatet
- Mohamed Ridha Tekaya
- Mohamed Aymen Ben Aissia
- Chantal Caouette
- Jean-Xavier Giroux
- Iris Klein
- Barbara Martel
- Renaud Patry
- Imen Zaier
- Mohammed Ali Ben Alaya
- Jean-François Bouchard
- Théodor Fiala
- Émilie Lamontagne

- Claudio Paniconi Hydrogeology
  - Cintia Racine
  - Judith Côté
  - Asma Chemingui
  - Mauro Sulis
  - Marie-Josée Gauthier
  - Catherine Guay
  - Marie Lefrancq
  - Giovanni Moretti
  - Lorenzo Sassi

- Marc Richer-LaFlèche Geochemistry
  - Yves Monette
  - Maxime Aubert
  - Yves Caron
  - Hilda Paucar Munoz
  - Nicolas Tremblay
  - Jean-François Boily (field assistant)
  - Édith Chouinard (field assistant)
  - Yvon Fortin (field assistant)
  - Simon Ouellet (field assistant)
  - Kevin Picard (field assistant)

- Pierre-Simon Ross Volcanology and geological economics
  - Julie Anaïs Debreil
  - Séverine Delpit
  - Russel Rogers

- Alain N. Rousseau Deterministic hydrology
  - Alain Royer
  - Sébastien Tremblay
  - Stéphane Savary
  - Sylvain Jutras
  - Martin-Pierre Lavigne
  - Fanny Quévy
  - Simon Ricard
  - Médard Bouda
  - Alexandru Ioan Ciobanas
  - Brou Konan
  - Sylvain Weill
  - Gwenael Carrer
  - Patrick Gagnon
  - Martine Grenier
  - Grégor Levrel
  - Muma Mushombe
  - Rémy Bourdillon
  - Clément Clerc
  - Brigitte Laberge
  - Philippe Noël
  - Sylvain Kouajou Akpo
  - Levent Demir
  - France-Line Dionne
  - Aimé Koudou
  - François Lasbleis
  - Johann Riedl
  - Jean Sentenac
  - Myriam Tremblay

- André Saint-Hilaire Statistical and environmental hydrology
  - Anik Daigle
  - Dae Il Jeong
  - Valérie Ouellet
  - Simon Tardif
  - Yves Tramblay
  - Mohammed Aziz Es Salhi
  - Nicolas Guillemette
  - Hélène Higgins
  - Sandra Proulx-McInnis

- Yves Secretan Hydro-informatics
  - Muluneh Admass Mekonnen
  - Pascale Matte
  - Ludovic Gardré
  - Jaime Jurado
  - Simon Pelchat
  - Pascale Dubé (liaison officer)

- Normand Tassé Geochemistry

- Rajeshwar Dayal Tyagi Decontamination
  - Sey-Hana Saing
  - Son Yan
  - François Chabot
  - Puspendu Bhunia
  - Pappy John Rojan
  - Kokou Adjalle
  - Jyothi Bezawada
  - Jean-Philippe Chenel
  - Zied Djedidi
  - Mathieu Drouin
  - Jean-Robert Gnepe
  - Amine Mahmoudi
  - Josée-Anne Majeau
  - Jia Miao
  - Ha Pham Thi Thanh
  - Sridhar Pili
  - Tarek Rouissi

- Bala Subramanian Sellamuthu
- Dang Khanh Vu
- Najib Mhamdi
- Jérémy Garcia
- Julie Querrec
- Marion Rivoal
- Benoit Salinier

■ Jean-Pierre Villeneuve Hydrology and integrated management

- Alain Garon
- Hong Trang Nguyen
- Phu Duc Nguyen
- Xuan Tuan Nguyen
- Thi Thu Ha Pham
- Annie Poulin
- Richard Turcotte
- Lise Audet
- Amélie Thériault
- Caroline Albert (secretary)
- Diane Dawson (secretary)
- Béatrice Morel (secretary)
- Diane Tremblay (secretary)

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Frank Berninger, UQAM

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Daniel Caya & René Roy, Ouranos Consortium

Joël Guiot, *Centre européen de recherche et d'enseignement des géosciences de l'environnement* (France)

Mario Bergeron

André Croteau & Jocelyne Osouf, *Institut national d'optique*

André L'Heureux, Phytronix Technologies

Monique Bernier

Michel Allard & Serge Payette, *Université Laval*

Philippe Beaucage, AWS Truewind (USA)

Julien Choisnard & Danielle De Sève, Hydro-Québec

Steven F. Daly, Cold Regions Research and Engineering Laboratory (USA)

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Chris Furgal, Trent University

Michelle Garneau, UQAM

Faye Hicks, University of Alberta

Gaëtan Lafrance, *INRS – Énergie Matériaux Télécommunications*

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Esther Lévesque, UQTR

Ralf Ludwig, Rostock University (Germany)

Eric Pottier, *Université de Rennes 1* (France)

Martin Tremblay, Kativik Regional Government

Peter G.C. Campbell

Jean-Charles Massabuau, *Université Bordeaux 1* (France)

Christophe Monnin, *Université Paul Sabatier* (France)

Bernard Roux, *Université d'Aix-Marseille* (France)

Bernard Vigneault, Natural Resources Canada

Karem Chokmani

Riadh Abdelfattah, *École Supérieure des Communications de Tunis* (Tunisia)

Patrice Couture

Louis Bernatchez, *Université Laval*

Gregory Pyle, Lakehead University

Christopher Wood, McMaster University

Patrick Drogui

Gérardo Buelna, *Centre de recherche industrielle du Québec*

Roger Lacasse, Premier Tech

Frédéric Lépine, Gecko Alliance Group

Sophie Duchesne

Marjorie Ramirez, *Ville de Québec*

Claude Fortin

Amiel Boullemant, Rio Tinto Alcan

Bermans Drouin, *Réserve faunique des Chic-Chocs*

Langis Fournier & René Lafond, *Ministère des Ressources naturelles et de la Faune du Québec*

Luc Gagnon, Groupe GDS

Catherine Jumarie, UQAM

Pierre Francus

Flavio S. Anselmetti, Swiss Federal Institute of Aquatic Science and Technology (Switzerland)

Daniel Ariztegui, *Université de Genève* (Switzerland)

Raymond S. Bradley & Laurie Brown, University of Massachusetts (USA)

Hugo Corbella, *Universidad Nacional de la Patagonia Austral* (Argentina)

Darrell Kaufman, Northern Arizona University (USA)

Scott Lamoureux, Queen's University

Andreas Lücke, Research Centre Jülich (Germany)

Nora I. Maidana, *Universidad de Buenos Aires* (Argentina)

Bernd Milkereit, University of Toronto

Christian Ohlendorf & Bernd Zolitschka, University of Bremen (Germany)

Frank Schäbitz, University of Cologne (Germany)

Doug R. Schmitt, University of Alberta

Stefan Wastegard, University of Stockholm (Sweden)

Erwan Gloaguen

Klaus Holliger, *Université de Lausanne* (Switzerland)

André Leite & Olivier Tavchandjian, Vale Inco

Denis Marcotte, *École Polytechnique de Montréal*

Yvan Petit, *École de technologie supérieure*

Stephane Rondenay, Massachusetts Institute of Technology (USA)

Charles Gobeil

Robie W. Macdonald, Fisheries and Oceans Canada

Lyal Harris

Laurent Godin, Queen's University

Isabelle Laurion

Marc Amyot, *Université de Montréal*

Beatrix Beisner, UQAM

Connie Lovejoy, Reinhard Pienitz & Warwick Vincent, *Université Laval*

Sally MacIntyre, University of California, Santa Barbara (USA)

Michel Malo

François Baudin, *Université Pierre et Marie Curie, Paris VI* (France)

Georges Beaudoin, *Université Laval*

Martin Bèche, Daniel Brisebois, Félix-Antoine Comeau & Bernard Granger, Pétrolia

Françoise Behar, François Lorant & Muriel Thibaut, *Institut français du pétrole* (France)

Yves Duchaine, Intragaz

Jean-Pierre Gratier, *Université Joseph-Fourier* (France)

Luc Massé, Junex

Nathalie Prudhomme & Jacques Simoneau, Opinaca Mines

Christine Saint-Laurent & Stephan Séjourné, Gastem

Richard Martel

Jaime M. Gárfias Soliz, *Universidad Autónoma del Estado de Mexico* (Mexico)

René Therrien, *Université Laval*

Guy Mercier

Martin Chantigny & Philippe Rochette, Agriculture and Agri-Food Canada

Jean-Louis Morel & Marie-Odile Simonnot, *Institut national polytechnique de Lorraine* (France)

Claudio Paniconi

Sihem Ben Abdallah & Feten Jarraya Horriche, *Centre de recherches et des technologies des eaux* (Tunisia)

Roberto Deidda, *Università di Cagliari* (Italia)

Isabelle Là Jeunesse, *Université d'Angers* (France)

Marie Larocque, UQAM

Stefano Orlandini, *Università di Modena e Reggio Emilia* (Italia)

Mario Putti, *Università di Padova* (Italia)

Pierre-Simon Ross

Michel Allard, Michel Dessureault & Gilles Roy, Xstrata Zinc Canada

Tony Brisson & Benoit Lafrance, Ressources Cogitore

Michel Chouteau, *École Polytechnique de Montréal*

Claude Dion, Jean Goutier & Marc Legault, *Ministère des Ressources naturelles et de la Faune du Québec*

Damien Gaboury, UQAC

Eric Grunsky, Vicki McNicoll & John Percival, Geological Survey of Canada

Alain N. Rousseau

Mohamed Amrani, Paul B. Jiapizian, Elizabeth Roberts & Serge Villeneuve, Environment Canada

Daniel Blais & Maryse St-Pierre, *Ministère du Développement durable, de l'Environnement et des Parcs du Québec*

Isabelle Chartier, Luc Roy & René Roy, Ouranos Consortium

Jacques Deschênes, *Ville de Québec*

Danielle De Sève, *Institut de recherche d'Hydro-Québec*

Julie Deslandes, *Institut de recherche et de développement en agroenvironnement*

Brook Harker & Éric van Bochove, Agriculture and Agri-Food Canada

Richard Turcotte, *Centre d'expertise hydrique du Québec*

Alfons Weersink & Wanhong Yang, Guelph University

André Saint-Hilaire

Daniel Caissie, Marie Clément & Simon Courtenay, Fisheries and Oceans Canada

Malcolm Conly & Jean Morin, Environment Canada

Philippe Gachon, Ouranos Consortium

Michel Lapointe, McGill University

Marc Mingelbier, *Ministère des Ressources naturelles et de la Faune du Québec*

Luc Roy & Nathalie Thiémonge, Hydro-Québec

Yves Secretan

André Luiz Amarante Mesquita & Claudio José Cavalcante Blanco, *Universidade Federal do Pará* (Brazil)

Pascale Biron, Concordia University

Manoel José dos Santos Sena, *Instituto de Estudos Superiores da Amazônia* (Brazil)

André Roy, *Université de Montréal*

Other professors

Emeritus

Georges Drapeau
Michel Slivitzky

Honorary

Aïcha Achab
Jean-Pierre Fortin
Guy Morin
Jean-Louis Sasseville
Alain Soucy
André Tessier

Associate

Guy Ampleman, DRDC-Valcartier
Marc Barbet, Hydro-Québec
Jean H. Bédard, GSC-Quebec
Christian Bégin, GSC-Quebec
Andrée Bolduc, GSC-Quebec
Sébastien Castonguay, GSC-Quebec
Louise Corriveau, GSC-Quebec
Benoît Dubé, GSC-Quebec
Mathieu J. Duchesne, GSC-Quebec
Donna Kirkwood, GSC-Quebec
Denis Lavoie, GSC-Quebec

Patrick Mercier-Langevin, GSC-Quebec
Yves Michaud, GSC-Quebec
Jean Morin, Environment Canada
Léopold Nadeau, GSC-Quebec
Miroslav B. Nastev, GSC-Quebec
Michel A. Parent, GSC-Quebec
Luc Perreault, Hydro-Québec
Didier Perret, GSC-Quebec
Reinhard Pienitz, *Université Laval*
Nicolas Pinet, GSC-Quebec
Christine Rivard, GSC-Quebec
Alfonso Rivera, GSC-Quebec
Martine M. Savard, GSC-Quebec
Sonia Thiboutot, DRDC-Valcartier

Other students

Supervised by associate professors

Anne-Laure Bonnet (PhD student, Louise Corriveau)
Annick Doucet (PhD student, Martine M. Savard)
Mathieu Gingras[1] (Master's student, Christian Bégin)
Abhidheya Wricht Holfeld (Master's student, Patrick Mercier-Langevin)

In the Professional Master's program

Sanaa Benamar
Daniel Bessette
Marie-Andrée Boisvert
Martin Genest
Marianne Métivier
Maggy P. Rousseau
Martin Tremblay

Lecturers

Michel Beaulieu
Louis Fontaine
Bernard Gaboury
Claude Jean
Yvon Maranda
Luc Valiquette

[1] graduated during the year

Invited professors and researchers

From abroad

Todd Arbetter, British Antarctic Survey (UK)

Khalidou M. Bâ & Jaime M. Gárfias Soliz, *Universidad Autónoma del Estado de México* (Mexico)

András Bárdossy, *Universität Stuttgart* (Germany)

Françoise Behar & Muriel Thibaut, *Institut français du pétrole* (France)

Ridah Ben Cheikh, *École nationale d'ingénieurs de Tunis* (Tunisia)

Guy Caniaux, *Centre national de recherches météorologiques* (France)

Alin A. Cârsteanu, *Instituto Politécnico Nacional* (Mexico)

Bernard Chocat, *Institut national des sciences appliquées de Lyon* (France)

Daniel Cossa, *Institut français de recherche pour l'exploitation de la mer* (France)

Jean-Pierre Dedieu, LARHR-CNRS (France)

Jean-Louis Goergen, Jean-Louis Morel & Marie-Odile Simonnot, *Institut national polytechnique de Lorraine* (France)

Stuart Lane, Durham University (UK)

Corrine Leyval, LIMOS-CNRS (France)

Emmanuel Naffrechoux, *Université de Savoie* (France)

Eric Pottier, *Institut d'électronique et de télécommunications de Rennes* (France)

Louis Prieur, *Laboratoire d'océanographie de Villefranche* (France)

Mathieu Ribatet, *École polytechnique fédérale de Lausanne* (Switzerland)

Éric Sauquet, CEMAGREF (France)

Gozo Tsujimoto, City College of Technology (Japan)

Jaume M. Verges, *Institut de Ciències de la Terra Jaume Almera* (Spain)

Alan L. Watchman, Australian National University (Australia)

Tran Minh Y, *Académie des sciences et des technologies du Vietnam* (Vietnam)

Fumihiko Yamada, Kumamoto University (Japan)

Fatiha Zidane, *Université Hassan II* (Maroc)

From Canada

Marc Amyot, *Université de Montréal*

Philippe Archambault, *Institut Maurice-Lamontagne*

Simon Barnabé, EcoNovo

Hamel Benmoussa, *Centre de recherche industrielle du Québec*

Louis Bernatchez, Christian Genest, Mir Abolfazo Mostafavi & André P. Plamondon, *Université Laval*

Amiel Boullement, Rio Tinto Alcan

Thomas Buffin-Bélanger & Bernard Hétu, UQAR

Daniel Caissie, Marie Clément, Simon Charles Courtenay & Peter Galbraith, Fisheries and Oceans Canada

Stéphane Campeau, UQTR

Daniel Caya, René Roy & Luc Vescovi, Ouranos Consortium

Martin Chantigny, Michel Nolin, Philippe Rochette & Éric van Bochove, Agriculture and Agri-Food Canada

Louis Delorme & Vincent Fortin, *Institut de recherche d'Hydro-Québec*

Philippe Gachon, Environment Canada

Pierre-Louis Gosselin, *Institut national de santé publique du Québec*

William J. Kamphuis & Scott Lamoureux, Queen's University

Robie W. Macdonald, Institute of Ocean Sciences

Yvon Maranda, *Ministère du Développement durable, de l'Environnement et des Parcs du Québec*

Stéphane Masson, *Parc Aquarium de Québec*

Marc Mingelbier, *Ministère des Ressources naturelles et de la Faune du Québec*

John F.V. Riva, consultant

Ousmane Seidou, University of Ottawa

Bruno Tremblay, McGill University

José R. Valéro, consultant

Kevin J. Wilkinson, *Université de Montréal*

Xuebin Zhang, Meteorological Service of Canada

Services

Direction

Yves Bégin (director)
- Roxane Dubé
- Isabelle St-Jacques

Administration

Nicole Laflamme (service head)
- Dominique Cantin
- Diane Lortie
- Julie Matte
- Marie-Noëlle Ouellet
- Mylène Paradis
- Manon Poitras
- Louise Robitaille

Building

Serge Marcoux (service head)
- Céline Bélanger
- Jean-Léon Doyon
- Gilles Guérin
- Éric Lortie
- Alain Poirier
- Pierre Tailleur

Cartography

- Marco Boutin

Documentation and information

Jean-Daniel Bourgault (service head)
- Pascale Dion
- Isabelle Martineau
- Chantal Paquin
- Anne Robitaille
- Jean-Michel Thériault

Teaching

- Johanne Desrosiers
- Suzanne Dussault

Computer service

Claude Blanchette (service head)
- Claude Champagne
- Martin Gagné
- Luc Jalbert
- Patrick Laforte
- Marc Saint-Pierre

Laboratories

Stéfane Prémont (service head)
- Anissa Bensadoune
- Michelle Bordeleau Geoffroy
- Sébastien Duval
- Pauline Fournier
- Philippe Girard
- Réal Gosselin[1]
- Marc Greendale
- Sandra Jobidon
- Julie Perreault
- Lise Rancourt
- René Rodrigue

Valorization of research

- Carole Parent

Interns

- Vincent Boulanger-Martel
- Jacques Gauthier-Duchesne

[1] left during the year

Financial report

Revenues and expenses of operating fund (x $1000)

For the financial year ending May 31, 2009

Revenues		
Total institutional revenues		9 321
Other revenues		2 701
Research grants		
• NSERC	2 950	
• FQRNT	341	
• Other sources	2 782	
Total grants		6 073
Research contracts		5 342
Total revenues		23 437
Expenses		
Research and teaching		17 073
Support for research and teaching		
• General administrative costs	1 608	
• MAO purchases (furnishings, instruments, and equipment)	65	
• Documentation and editing	422	
• Direction of Centre	336	
• Computer service	285	
• Laboratories	636	
• Land and buildings	1 879	
• Geological Survey of Canada (GSC) Agreement	231	
• Large-scale laboratories	492	
• Research station	14	
Total support for research and teaching		5 968
Total expenses		23 041
Excess of revenues over expenses		**396**
Transfer to capital fund		0
Net excess of revenues over expenses		**396**

Financial report

Reserves of the Centre (x $1000)

For the financial year ending May 31, 2009

Operating fund reserve	
Accumulated surplus on 31 May 2005	1 711
Operating surplus on 31 May 2006	540
Revised operating surplus on 31 May 2007	942
Operating surplus on 31 May 2008	448
Operating surplus on 31 May 2009	396
Total surplus	4 037

Capital fund reserve	
Unused balance on 31 May 2005	745
Balance transferred 2005-2006	550
Balance transferred 2006-2007	900
Adjustment 2005-2006	1 442
Unused total balance on 31 May 2006	3 637
Use of funds to finish reimbursing Édifice Québec	-2 853
Unused balance forecasted on 31 May 2007	784
Unused balance on 31 May 2008	131
Unused balance on 31 May 2009	127

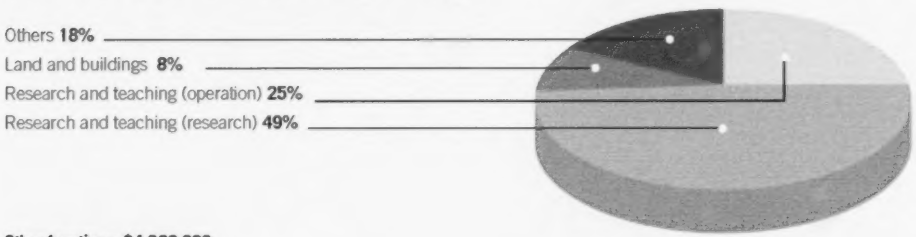
Financial report

University expenses by function (x $1000)

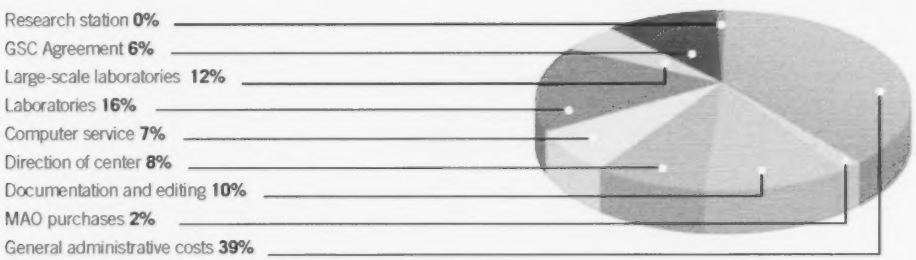
For the financial year ending May 31, 2009

	Salaries, benefits and scholarships	Field work, travel, supplies and material	Professional, contractual and public services; rent	Total
Research and teaching (operation)	4 664.2	49.4	945.3	**5 659**
Research and teaching (research)	5 540	1 155.0	4 720	**11 415**
General administrative costs	793.9	16.1	797.8	**1 608**
MAO purchases (furnishings, instruments, and equipment)	0	0	65.3	**65**
Documentation and editing	324.2	0.8	96.9	**422**
Direction of Centre	296.2	24.9	14.8	**336**
Computer service	412.7	0.1	-128.8	**284**
Laboratories	446.4	0.1	189.4	**636**
Land and buildings	344.5	2.3	1 532.4	**1 879**
Geological Survey of Canada (GSC) Agreement	175.5	16.5	38.6	**231**
Large-scale laboratories	46.1	1.3	444.3	**492**
Research station	2.0	1.1	11.4	**14**
Total	13 046	1 268	8 727	23 041

Research, teaching, land and buildings, and others: $23 041 000



Other functions: $4 088 000



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